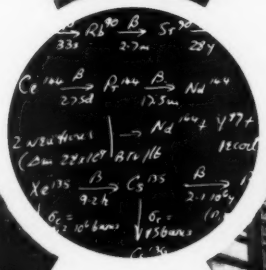
A ROWSE MUIR PUBLICATION

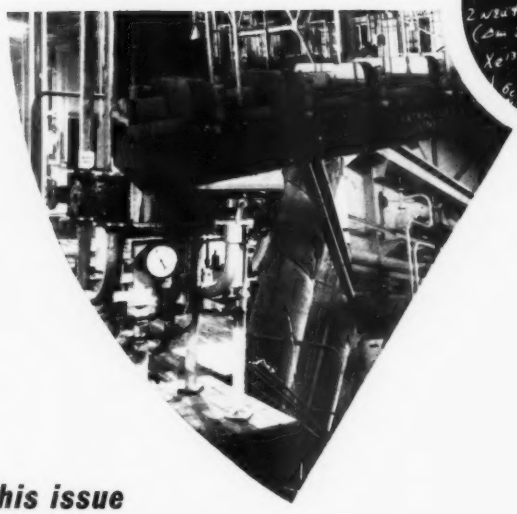
Nuclear Power

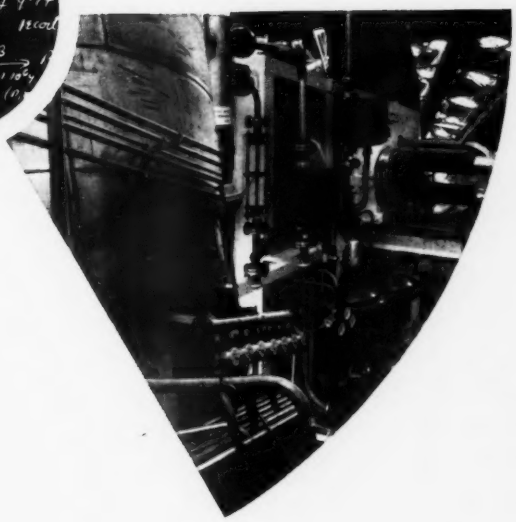
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

Criticality problems in chemical plant

. . . page 97







Also in this issue

Italy's BWR power station

— first full description

October 1959 monthly 3/6

Tick **No 2** on reply card for further details

Nuclear Octave

Eight specialist companies make up the nuclear octave. Each sounds exactly the right note in terms of its own particular skills and experience. In combination they form N.P.P.C. which thus has all the resources necessary for the construction of complete nuclear power stations throughout the world.

At Bradwell, Essex, N.P.P.C. are building a new nuclear power station for the Central Electricity Generating Board, with a guaranteed output of 300 megawatts. This great enterprise is a commercial venture aiding Britain's economy and emphasising her world lead in the practical application of atomic power for peace.

NPPC

A Greater Britain through Nuclear Power

THE NUCLEAR POWER PLANT COMPANY LIMITED

C. A. PARSONS AND COMPANY LIMITED · A. REYROLLE AND COMPANY LIMITED
HEAD WRIGHTSON AND COMPANY LIMITED · SIR ROBERT McALPINE AND SONS LIMITED
WHESSOE LIMITED · STRACHAN AND HENSHAW LIMITED
ALEX FINDLAY AND COMPANY LIMITED · CLARKE CHAPMAN AND COMPANY LIMITED

BOOTHS HALL · KNUTSFORD · CHESHIRE

TGA NP2

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

VOL 4 NO 42 OCTOBER 1959

MANAGING DIRECTOR A. H. David Rowse, MA
EDITORIAL DIRECTOR Caldwell Davidson MSC(ENG), DIC

EDITORIAL
EDITOR John Woodeson, BSC(ENG)
FEATURES EDITOR Patricia May, BSC
NEWS EDITOR Charles E. Steiner
EDITORIAL ASSISTANT Angela Funnell
PRODUCTION MANAGER Gerald Vane, BA (CANTAB)
PRODUCTION ASSISTANT Gerald Withers
CIRCULATION MANAGER J. W. Rotheroe, BSC(ECON)
CIRCULATION ASSISTANT E. A. Hutcheson

CONSULTANTS
INSTRUMENTATION Denis Taylor, PHD, MIEE, FIP
PHYSICS James F. Hill, BSC
METALLURGY Prof J. G. Ball, BSC, FIM
ISOTOPES A. G. Maddock, MA, PHD, DIC

ADVERTISEMENTS
DIRECTOR Harry T. Kane
ADVERTISEMENT MANAGER John Abram
SOUTHERN REPRESENTATIVE K. M. Towell
CLASSIFIED ADVERTISEMENTS John Deamer

MANCHESTER OFFICE
Barry Gibbs
18 Grangeway, Handforth, Cheshire
tel: Wilmslow 2600

NEWCASTLE OFFICE
Peter Doig
14 Neville Street, Newcastle 1
tel: Newcastle 20945

FRENCH OFFICE
M. B. Lebovic & G. Leterrier,
36 rue du Fer-à-Moulin,
Paris 5 eme, France
tel: POR 53-59

U.S. OFFICE
Walter J. Masterson, Jr
Box 206, Essex, Conn. *tel:* South 7-1838

NUCLEAR POWER is published by Rowse Muir Publications Ltd, 3 Percy Street, London, W1, England, and printed by The Haycock Press Ltd, SE5. The entire contents are protected by copyright in Great Britain and by the Universal Copyright Convention but matter may be reproduced provided that due acknowledgment is made to NUCLEAR POWER. Subscriptions to publishers Rowse Muir Publications Ltd. Single copies UK 3/6, 5/6 overseas, 75c US and Canada. Per annum £2.2.0 UK, £3.3.0 overseas, $8.0 US and Canada plus 50c postage.

RM

SPECIAL FEATURES

Italy's second nuclear power station
V. A. Elliott and G. J. Stathakis of US General Electric describe the SENN BWR station, the first in the world to be awarded as a result of an open international competition 87

Discriminators in radiation counting
Continuing our series on electronics for radiation detection, F. H. Wells of Harwell outlines the part played by discriminators and discusses problems of circuitry 92

Criticality problems in chemical plant
Beginning a two-part article, Dr. G. Hall of Imperial College surveys the factors which influence the design of inherently safe plant for handling quantities of fissionable materials 97

Aluminium alloys for water-cooled reactors
R. B. Cotton of ICI Metals describes recent work on improving the corrosion resistance of aluminium alloys which could make them a more attractive possibility for both fuel cans and pressure vessels 100

Plutonium production at Argonne
The AEC's new glove box line, probably the most advanced of its kind in the world, recently went into production 108

NUCLEAR TECHNOLOGY

REACTORS:
Diffusion theory boundary conditions *by A. Jeffrey* 103

MATERIALS:
Deformation of alpha uranium *by R. Butcher* 105

INSTRUMENTATION:
Pulse transformers for counting *by A. L. Gray and R. Webster* 106

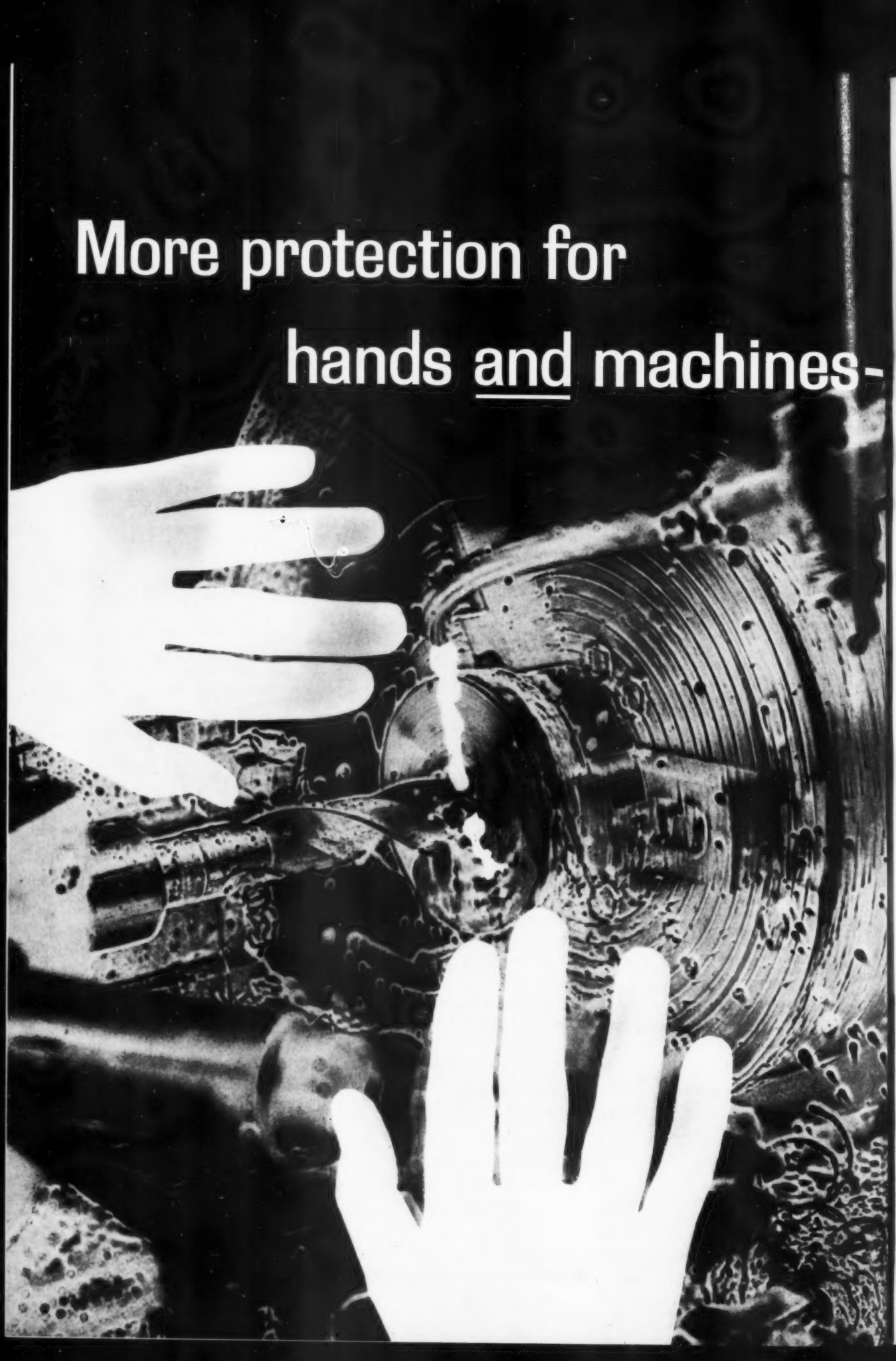
PROGRESS IN INDUSTRY

Irradiation services at Wantage
Britain's first full-scale source facility 110

REGULAR FEATURES

Publisher's Column 75
Letters 77
Leader 81
Worldview 83
Cross-Section *Gracchus* 112
New Product Survey 113
Industrial Newsdesk 116
Points from Papers 122
Names in the News 124
Catalogues and Bulletins 124
Book Reviews 126
Classified Advertisements 158

ROWSE MUIR PUBLICATIONS LTD, 3 PERCY STREET, LONDON, W1, ENGLAND tel: Museum 8252


More protection for
hands and machines-

New Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, the Shell range of Dromus Oils has been reformulated and these new cutting oils, now bland, considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the pleasant position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

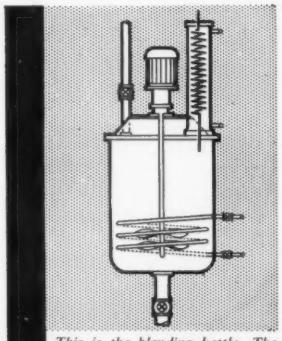
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors to produce the right oil for the job. If you and your organization have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

NEW SHELL DROMUS SOLUBLE CUTTING OILS

another proof of Shell leadership in lubrication

Tick **No 3** on reply card for further details

CON-TEN
(Regd. Trade Mark)

constant tension supports

FOR LOADS UP TO 8 TONS
PIPE MOVEMENTS UP TO 18"

High-pressure steam piping is subject to wide variations in temperature, which produce considerable expansion and contraction. Unless the pipe supports can absorb and compensate for this movement, severe stresses are set up which may result in fracture. The "Con-Ten" Pipe Support is designed to cradle any type of piping with constant tension under all conditions, throughout the range of movement. "Con-Ten" is installed, with eminently satisfactory results, in power stations, oil refineries, chemical and industrial plants throughout the world.

British Patent No. 474008, 720074, 720075, 697987, 657318
U.S.A. Patent No. 2129320

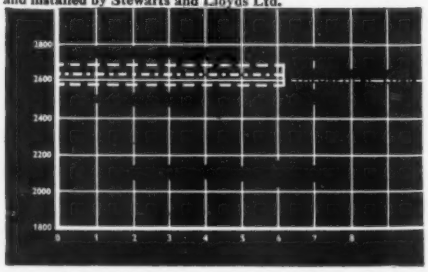
Ferrybridge 'B' Power Station, Central Electricity Generating Board, Yorkshire Division. H.P. Steam pipes supplied and installed by Stewarts and Lloyds Ltd.

Lettered Red Top Pipe Supports for loads from 100 to 5,000 lbs. and total travel of 3".

Conventional type "Con-Ten" Supports for loads of up to 2 tons with a total vertical movement up to 12".

Duplex "Con-Ten" Supports for loads of up to 8 tons with a total vertical movement up to 12". This type is acknowledged as one which produces minimum friction and kinematic variation. It has been specially designed for any applications where exceptional accuracy is demanded,

From graph it can be seen that the maximum friction is equivalent to 2.17% of the applied load.

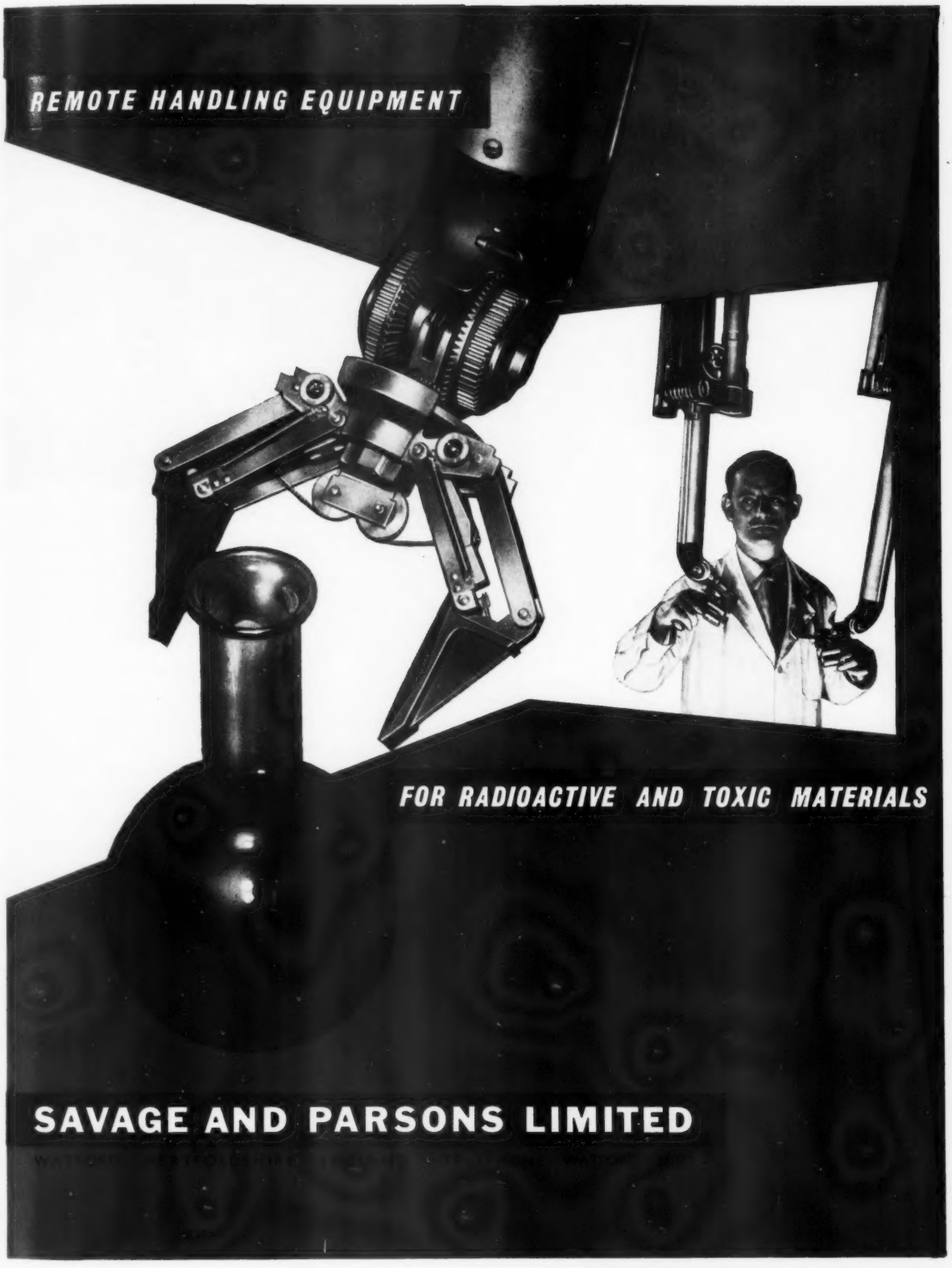


DUPLEX 'CON-TEN' SUPPORT

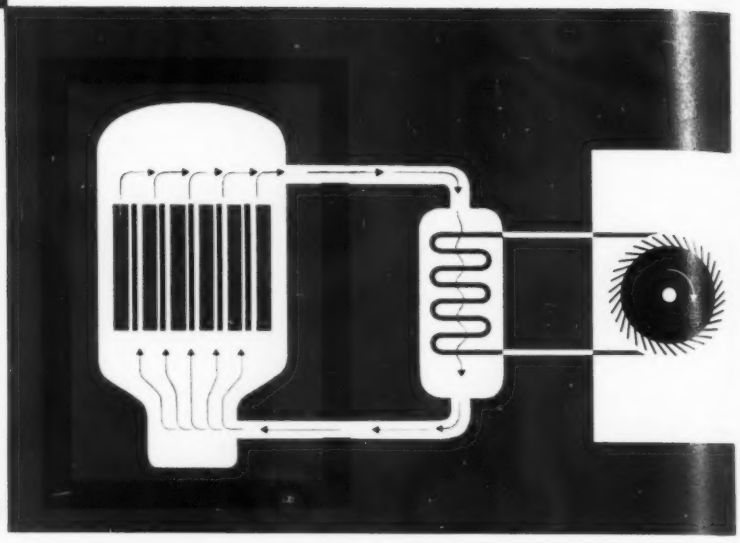
BRITISH INDUSTRIAL

ENGINEERING COMPANY (STAFFS) LIMITED

CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS. TEL.: TIPTON 1222/3/4


REMOTE HANDLING EQUIPMENT
FOR RADIOACTIVE AND TOXIC MATERIALS
SAVAGE AND PARSONS LIMITED

Structural Elements for Nuclear Reactors



can only be manufactured in most up-to-date finishing plants, in which quality of the material and precision of workmanship combined with wide experience guarantee maximum safety of our products. These prerequisites are largely fulfilled by Phoenix-Rheinrohr. Sufficient proof of this are our achievements in the field of thick plates in standard and clad execution.

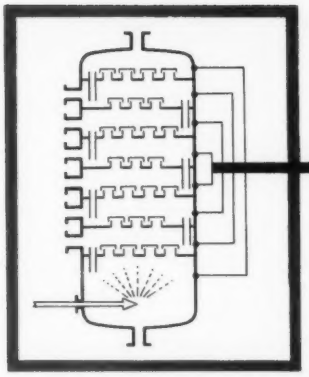
In our plants we manufacture and deform clad plates up to total thicknesses of 250 mm.

For nuclear energy plants we supply:

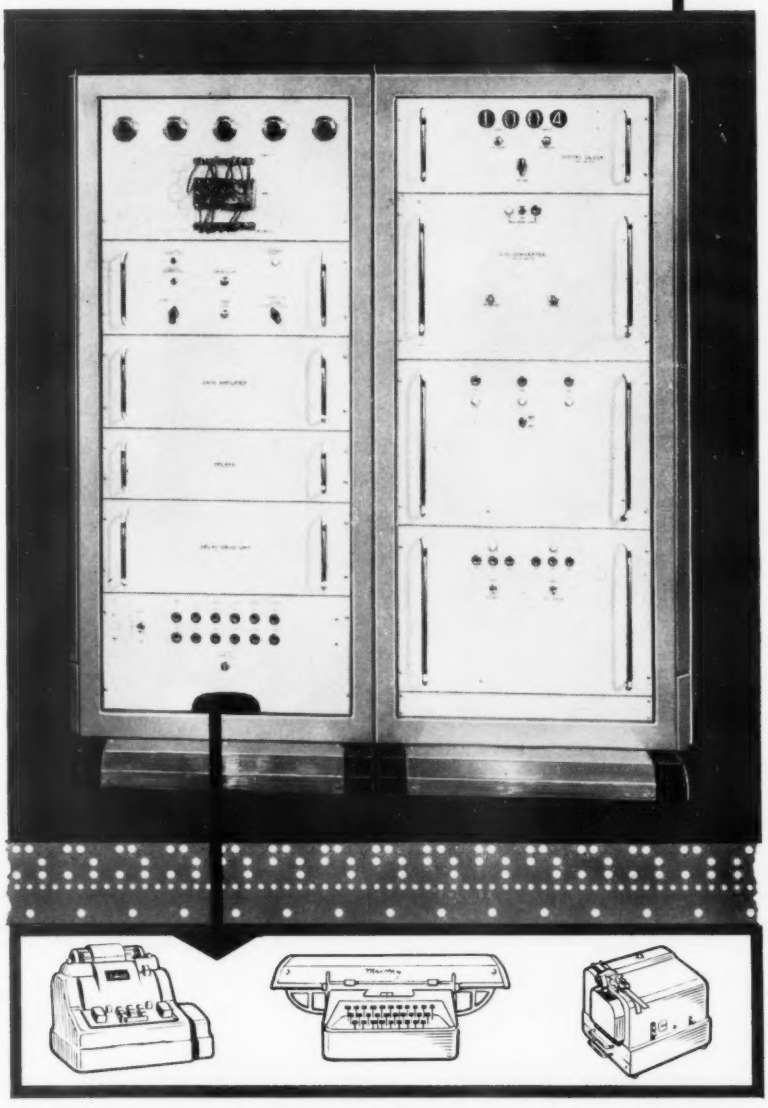
Heavy plates made of carbon and alloyed steels in wall thicknesses between 5 – 250 mm
Plates made of high alloy steels, from 1 mm thickness
Clad medium and heavy plates up to a total thickness of 250 mm
The following products made of normal and clad plates:
Reactor pressure vessels, thick-walled containers
Cylindrical shells
Pressed heads
Segments for large heads and spherical containers
Other containers
Moreover:
Seamless steel tubes made of high temperature, corrosion resistant and unalloyed steels
Welded small-size and big-size tubes made of unalloyed and alloyed steels
Heat exchangers, tubular coils, pipelines
Tubular bends, fittings and flanges, alloyed and unalloyed
Sectional steel made of unalloyed, alloyed and special steels

PHOENIX-RHEINROHR AG
VEREINIGTE HÜTTEN- UND RÖHRENWERKE DÜSSELDORF GERMANY

Monitor 1000
" readings " every
50 seconds with



Data Logging Equipment



An accuracy of ±0·2% and a high scanning speed make Blackburn Electronics data logging equipment ideal for monitoring plant performance. Modular construction of the basic units enable instrument engineers to install exactly the right size of this inexpensive and compact equipment necessary for data monitoring and recording on their plant. Extension of the logger by multiples of 10 channels is possible as required.

Input signals derived from thermocouples and other transducers can be scanned at a rate up to 20 points a second. Departure of any parameter from predetermined limits is indicated by visual and audible alarms and a parameter record. Alarm conditions may also open relay contacts for process control applications. The output data may be obtained on a strip or page printer or paper tape punch and will comprise parameter identification, value and time, etc.

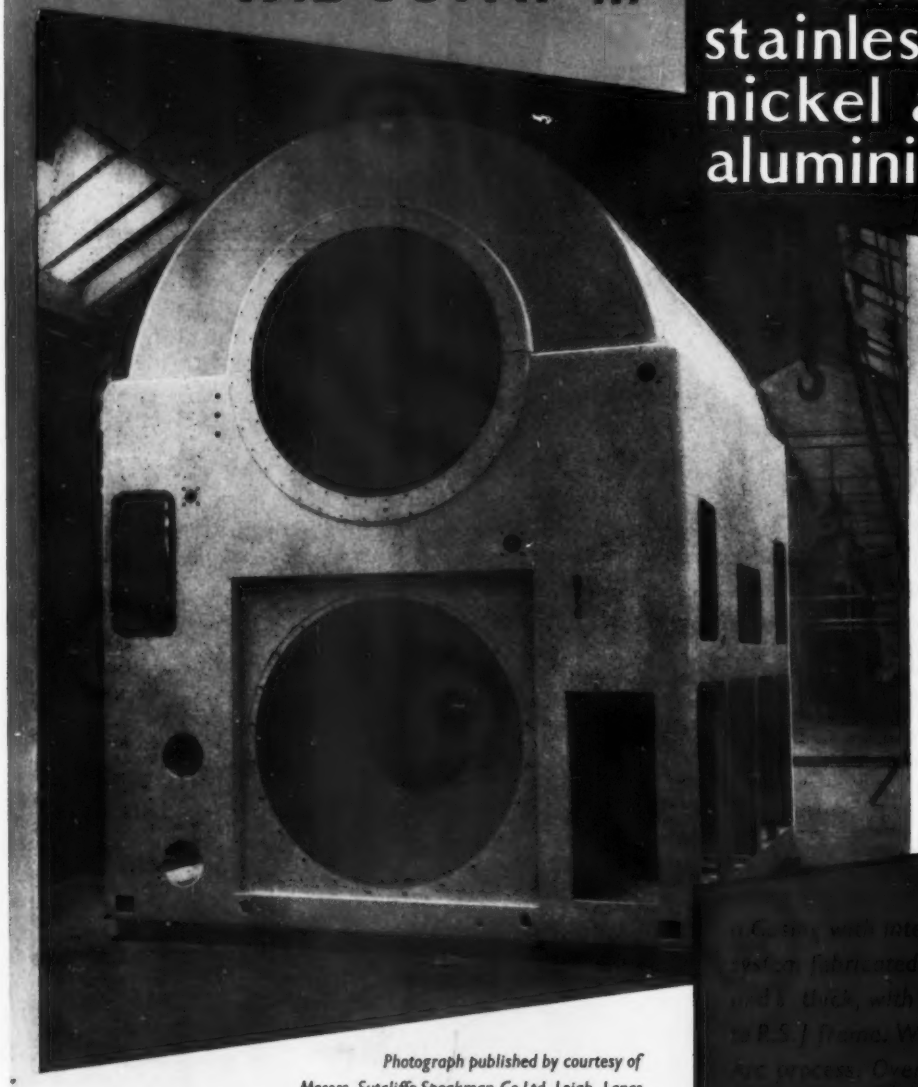
A complete log of all parameters may be obtained on demand and at regular intervals.

BLACKBURN ELECTRONICS LIMITED

Brough, Yorkshire Telephone : Brough 121

FABRICATORS to INDUSTRY in

···· mild steel, stainless steel, nickel and aluminium etc.



Photograph published by courtesy of Messrs. Sutcliffe Speakman Co.Ltd, Leigh, Lancs.

UNIVERSAL BOILERS & ENGINEERING CO. LTD

HEAD OFFICE: FULLEDGE WORKS - BURNLEY - LANCASHIRE - ENGLAND
Telephone 3121/2 and 3203 Burnley (3 Lines) Telegrams: 'UNIVERSAL' Burnley

Associated with BURNLEY AIRCRAFT PRODUCTS LTD. Fulledge Works Burnley Telephone: 3121/2
GROSVENOR STREET, STONEYHOLME, BURNLEY Telephone: 3184
and BRITANNIA WORKS, QUEENSGATE, BURNLEY Telephone: 4102

FACTS you should know about commercial uranium

Outmodes many present metals and methods - safely and at low cost

What is Commercial Uranium?

Commercial (depleted) Uranium—the uranium isotopes remaining after the removal of U-235 (with *radiation exposure about equal to that obtained in watching your TV set*)—possesses many inherent qualities of interest to many industries.

Uranium has many interesting properties.

For example, Davison Uranium has exceptional density —*68% greater than lead* and about equal to gold. This indicates usages as counterweights in aircraft, shipbuilding, tool making industries—wherever high weight and low volume are factors. It alloys readily with many metals including aluminum, chromium, copper, iron, manganese, molybdenum, niobium, nickel, silicon and zirconium. Corrosion resistance is increased when uranium is alloyed with one of these metals. Davison Uranium possesses high tensile strength and low thermal expansion. While fairly hard (Brinnell 240) at room temperature, uranium becomes very malleable as temperature rises. At 1100° F. its hardness drops to about 20.

Is Davison Uranium easy to fabricate?

Davison Uranium may be melted and cast into any desired shape. It may be formed by extrusion, drawing, rolling, swaging, pressing or forging.

You can machine Commercial Uranium with conventional carbide-tipped machine tools, bearing in mind that it has work-hardening characteristics similar to those of stainless steel.

It is necessary to machine uranium under water soluble lubricants. Commercial Uranium has been machined on a number of tools including lathes and automatic screw machines, saws, high-speed mills and centerless and surface grinders.

How about welding?

Success in welding Davison Uranium has been achieved using the Heliarc and shielded arc-consumable electrode process. At this date experiments continue in joining uranium to uranium by brazing or soldering.

How has Commercial Uranium been used?

Present applications include shielding materials, teletherapeutic heads, isotope containers; as counterweights and static balances. And, for many years, as coloring agents and glazes.

Is Davison Uranium safe?

Radiation hazards are minor. AEC tests indicate that *a week's exposure* to depleted Uranium is only about *1/10th to 1/100th* the radiation received from an *ordinary chest X-ray*.

However, just as other heavy metals such as lead are toxic if breathed, care must be exercised to avoid inhalation of uranium dusts. A properly ventilated work area removes this dusting problem.

Must special storage precautions be taken?

Uranium metal (except fines) can be *handled and stored with methods similar to those used with any other massive metal*. Fines, however, are flammable and should be stored under oil or water.

Is Commercial Uranium expensive?

Not at all. For example, in lots of 1400 pounds or more Commercial Uranium is priced at just $4.60 per pound —considerably cheaper than other heavy metals, with the advantage of superior density.

Need more information?

A letter will bring you additional details for the application of Commercial Uranium to your products or processes. Write today to Department B-210, Erwin, Tennessee.

do!

W.R. GRACE & CO.
DAVISON CHEMICAL DIVISION
ERWIN, TENNESSEE

Fielden Controllers mounted on the sloping panel of a Brown Davidson Moulding Machine

NEW BIKINI

TRANSISTORISED TEMPERATURE CONTROL to within 0.5° C

The first of Fielden's new BIKINI range of transistorised instruments. Result of three years intensive research, development and evaluation. Small in size and small in price, yet all essentials more than covered. In brief, it's appealing.

Low Cost—Send for details, you'll be surprised.
Transistorised—Exceptional reliability. No warming up period. 12V Battery or mains supply.
Intrinsic Safety—Low voltage, low current operation—Intrinsic safety certificate pending.
Very Robust—completely sealed unit requires no attention. No pivots, galvos or other delicate moving parts.
Easily fitted—simple clamp mounting with robust terminals for electrical connections. Can be mounted at any angle, for example on a sloping control panel.
Remote control—Instrument can be up to 300 ft away from the measuring point using simple copper wiring. Measuring element is of platinum resistance type, housed in a robust ¼" diameter stainless steel sheath.
Heavy Duty Contacts—Change over electrical contacts rated at 5 amps A. C. with quick make and break action. Pneumatic control available if required.
Accurate calibration—Accurately calibrated scale 9" long marked in °C or °F. Easily set to required control temperature.
High stability—Control point will not vary over many years service. Unaffected by ambient temperature changes or by wide variations in supply voltage.
Wide Temperature range—will control at any temperature between —200° C and +500° C with a differential of 0.5° C. Range spans as low as 50° C.
Modern and Compact—Circular meter type case. Occupies panel space of only 4½" diameter. Bold pointer shows control temperature. Red lamp, visible from sides and front, indicates control action.
Immediate delivery—Instruments ranged 0-120° C, 0-200° C, 0-300° C and 0-500° C available from stock in Manchester, London, Walsall, Stockton and Edinburgh. Other standard ranges in stock at Manchester. Telephone your urgent requirements to Wythenshaw 3251 Trafalgar 3154, Arbortum (Walsall) 55343, Stockton 68617 or Edinburgh 32035 (A. R. Bolton).

Write now for full specification sheet Bik/1/N.P. with price list.

FIT BIKINI AND WATCH YOUR CONTROL PROBLEMS SWIM AWAY

Fielden

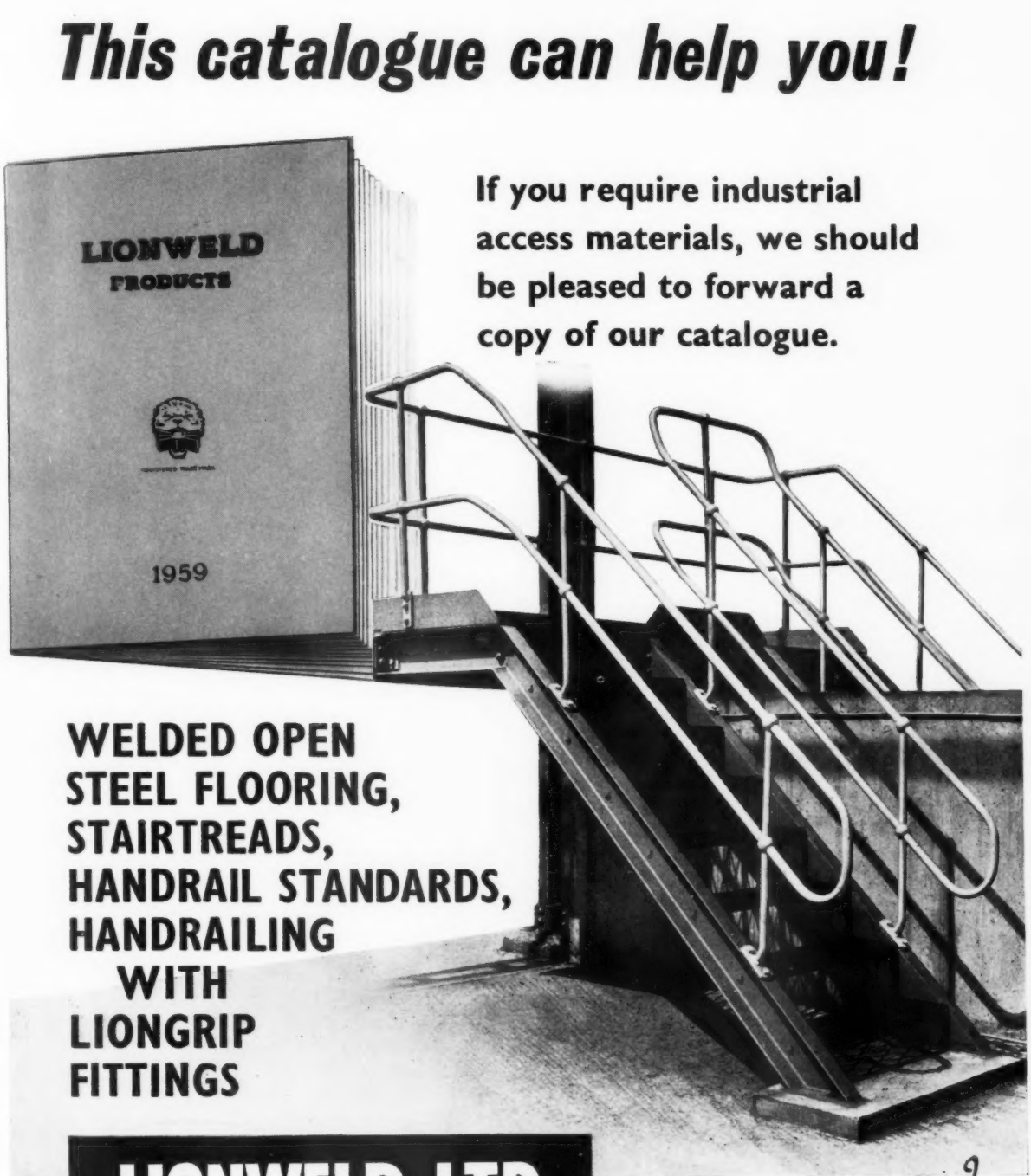
FIELDEN ELECTRONICS LTD · WYTHENSHAWE · MANCHESTER Phone : Wythenshawe 3251 (4 lines) Grams : Humidity Manchester
ALSO AUSTRALIA, ITALY AND CANADA *Branch Offices :* LONDON, WALSALL, STOCKTON-ON-TEES AND EDINBURGH

Indicating Recording Control

BI

This catalogue can help you!

If you require industrial access materials, we should be pleased to forward a copy of our catalogue.



WELDED OPEN STEEL FLOORING, STAIRTREADS, HANDRAIL STANDARDS, HANDRAILING WITH LIONGRIP FITTINGS

LIONWELD LTD
MARSH ROAD, MIDDLESBROUGH
Telephone: 45151 Telegrams: Lionweld

D.O. Have we a current copy? T.R.S.

the SERCK organisation
PRIMARY AND SECONDARY SURFACE HEAT EXCHANGERS
CONDENSERS
AIR AND GAS COOLERS
CONDENSER TUBES
SERCK RADIATORS LIMITED
SERCK TUBES LIMITED

SPECIAL STEELS FOR NUCLEAR POWER . . .

One of the most essential characteristics implied by the expression 'high quality' is reliability, and the construction of nuclear power plants ranks high amongst those advanced engineering projects, where any doubt concerning the materials of construction cannot be tolerated

Hadfields have contributed in the provision of high quality alloy steels to meet the demand of reactor designers and the "Era" series of Boron Steels was developed to satisfy the special needs of neutron absorption for control purposes. These steels are also used for special shielding applications.

Hadfields have made the Control Rods for Calder Hall and Chapelcross Stations of U.K.A.E.A., incorporating "Era Boron Steels" and "Era H.L.C." special Low Cobalt Stainless Steel. "Era H.L.C." Steel has also been used in the production of a number of other reactor components and is of the 18/8 Stabilised type.

Pressure vessel and heat exchanger forged flanges are made in special "Era C.R." and "Hecla" Steels, and a large number of small castings can be produced in our foundries which are specially equipped for this class of work.

HADFIELDS SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.

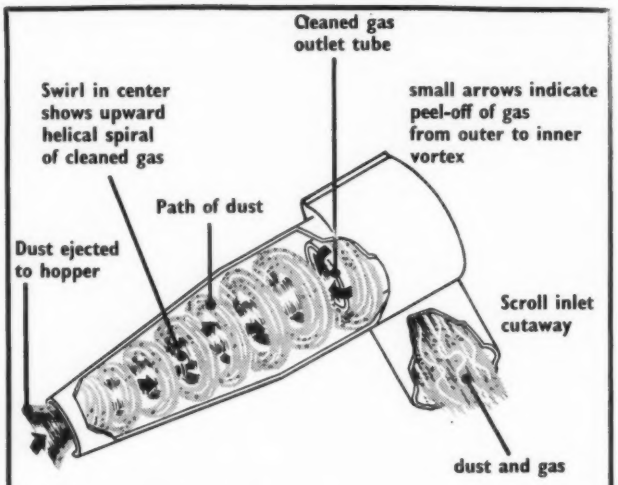
THE MANCUNA MINIATURE CYCLONE HIGH EFFICIENCY DUST COLLECTOR

If you have a problem of valuable powder recovery, boiler grit emmission or high efficiency gas cleaning and dust collection, you are invited to enlist the help of our technical service department.

The infallible reliability and exceptional efficiency of Mancuna-Dustex miniature cyclone dust collectors, justifies their reputation as the most efficient mechanical collector in the world.

On these primary factors rests the decision of the Nuclear Power Plant Co. Ltd. to use Mancuna-Dustex By-Pass and Drier Filters.

Construction. Cast Meehanite Iron.
Maintenance Factor. Nil.
Life. Indefinite.
Efficiency. Approaching 100% down to to 10 at 4.5 p.s. press Load.


Cleaned gas outlet tube
Swirl in center shows upward helical spiral of cleaned gas
small arrows indicate peel-off of gas from outer to inner vortex
Path of dust
Dust ejected to hopper
Scroll inlet cutaway
dust and gas

Main 18¼" tube body showing HELIX SPIRAL action

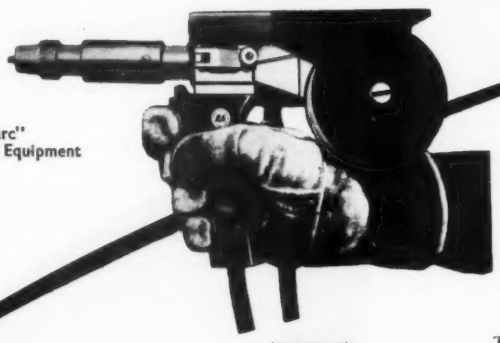
First - Bradwell, Essex . . . NOW AT LATINA, ITALY

IN CONJUNCTION WITH AGIP NUCLEARE AND THE NUCLEAR POWER PLANT CO. LTD.

MANCUNA ENGINEERING LTD., DENTON, MANCHESTER. Tel.: Denton 3965 (5 lines)
Specialists in Gas Cleaning and Dust Technology
London Office: 59 VICTORIA ROAD, SURBITON, SURREY. Tel.: Elmbridge 9793

MANCUNA

Co-ordinated Resources for Service in the Nuclear Field

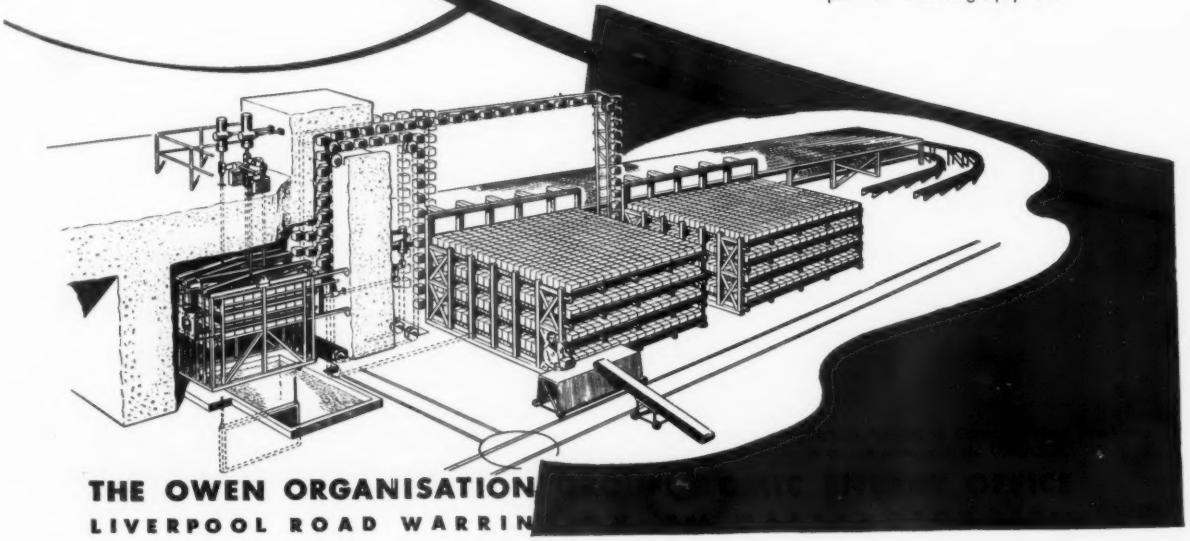


"Rowenarc"
Welding Equipment

The Owen Organisation

The resources of the Owen Organisation are co-ordinated to serve the Nuclear Industry in Design, Development and Manufacture

Arconarc Welding · Rowenarc Welding · Hydraulic and Pneumatic Actuating Systems and Valves · Design and Research Facilities · Prototype manufacture facilities · Production Facilities · Patented Copper free brazing for steel stainless steel, Niobium, etc · Fork Trucks and Materials Handling Equipment · Pressure Vessels · Test facilities, including Hydraulic Pneumatic, Mechanical · Test facilities for Prototypes · Structural Steel work · Metal Equipment, Partitioning, Bins and Furniture · Remote Control Equipment · Cold and Hot Presswork · Fabrication work · High Tensile Bolts · Package Irradiation Plants · Electro-Hydraulic Controls and Servos · Special Purpose Machinery and Machine Tools · Compressors · Oil Firing Equipment



THE OWEN ORGANISATION
LIVERPOOL ROAD WARRIN

Clean pair of heels

CAPOSITE Regd.

amosite asbestos preformed insulation

CAPOSITE means a clean and tidy site! No messy bits to stick to boots—Caposite is clean to cut and sweep away. It comes in light, easily handled, non-returnable cartons which make handy off-cut bins.

no mess-no waste

Write for full technical details to

THE CAPE ASBESTOS COMPANY LIMITED

114 & 116 PARK STREET LONDON W1 GROSVENOR 6022

GLASGOW: Hobden Street, Petershill Road, Glasgow, N1. Springburn 6144
MANCHESTER: Floor D. National Buildings, St. Mary's Parsonage, Manchester 3. Deansgate 6016-7-8
BIRMINGHAM: 11 Waterloo Street, Birmingham 2. Midland 6565-6-7
NEWCASTLE: 19 & 20 Exchange Buildings, Newcastle. Newcastle 20488

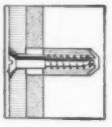
CAPE

TA.2071

MODERN MATERIALS NEED MODERN METHODS

Old-fashioned fixing methods are *always* wasteful, and often enough entirely inadequate for modern materials. Whatever the material—brick or glass, solid or cavity—you'll make absolutely firm screw or bolt fixings many times faster with Rawlplug Fixing Devices and Tools.

SCREW FIXINGS



RAWLPLUGS for neat firm fixings in brick, stone, etc. Rotproofed and waterproofed for use in all climatic conditions. All screw sizes up to ¾" diameter coach screws.

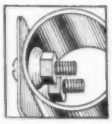
Rawlplug WHITE BRONZE PLUGS for fixings subject to very high temperatures, such as the outer brick coverings of furnaces. Also for underwater fixtures.

BOLT FIXINGS

RAWLBOLTS for bolting down machines—a rock-firm *dry* fixing that grips by expansion. No cold chiselling, no waiting for cement to harden. Sizes up to 1" bolt diameter.

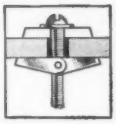
Rawlplug BOLT ANCHORS for bolting down in extremely wet or corrosive situations. Caulking completely seals the anchorage. Also for anchoring Diesel Generators, Power Hammers, etc.

CAVITY FIXINGS



Screwed up from the front, the amazing RAWLNUT forms its own rivet head behind the material—airtight, watertight, vibration-proof, squeak-proof. For all thin or hollow materials.

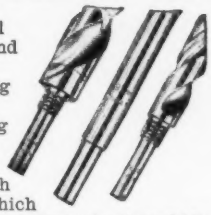
Rawlplug SPRING TOGGLES for ceilings of lath and plaster, plasterboard, etc. The Toggle springs open behind the material, spreading the load over a wide area.



RAWLPLUG DURIUM
THE FAST DRILLING, SILENT MASONRY DRILL— AND THE MOST DURABLE

With its ultra-tough, almost diamond-hard Durium tip, and its patented rapid-helix flute to force out spoil and prevent clogging, Durium drills brick, tile, cement, slate, marble, etc. with a speed of penetration that is truly amazing.
It is this same toughness of the Durium tip, and the stronger backing given it by the specially designed flute, that gives a Durium Drill its astonishing ability to stand up to the abrasive action of masonry which so quickly ruins ordinary drills.
Only a Durium Drill has such sharp, silent, easy cutting accuracy, such amazing drilling speed, such sheer durability!

FULL RANGE—DRILLING LENGTHS UP TO 16" TOO!



Durium Drills are made for all sizes of Rawlplugs from No. 6 to No. 30 (i.e. drill cutting diameters from 5/32" up to 1") and also for Rawlbolts sizes C, D, E & G.
Durium Drills are also made in the Long Series to facilitate the work of laying conduits, cables, pipes, etc. Five cutting diameters (⅞" up to 1¼") are available in 6" drilling lengths; six cutting diameters (⅝" up to 1") are available with threaded ends to take extension rods which provide for overall drilling lengths of approximately 12" and 16".

DURIUM *GLASS* DRILLS

These high-efficiency drills can be used in a wheelbrace or suitable electric drill. 9 cutting diameters, from ⅛" up to ¼".

BY HAND OR POWER

Durium Drills can be used very successfully in an ordinary wheelbrace, but where drilling is carried on fairly regularly, or on a large scale, a Rawlplug R.P.1. Slow Speed Electric Drill is a time-saver that will pay for itself over and over again. With full load speed of 450 r.p.m. this easy-to-handle power tool will give quite sensational results with Durium Drills.

FREE RE-SHARPENING SERVICE

When, at long last, your Durium Drill begins to lose its keenness, return it to us with the complimentary voucher supplied with it, and we'll re-sharpen FREE!
Durium Drills are sold in the bright orange and blue metal container clearly marked Rawlplug Durium. Look for the name DURIUM on the drill shank—no other is a genuine DURIUM Drill.

RAWLPLUGS

RAWLPLUG FIXING DEVICES AND TOOLS

21 different types of fixing devices for speed and strength

Write now for illustrated literature containing full details of Rawlplug Fixing Devices and the many high performance Rawlplug tools (hand, electric and pneumatic).

THE RAWLPLUG CO. LTD., CROMWELL ROAD, LONDON, S.W.7

The world's largest manufacturers of fixing devices

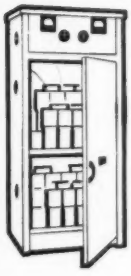
BATTERY SPACE

with the new TUDOR high performance stationary cell

Savings of up to 50% in the space required for a stationary battery are made with the introduction of a new Tudor cell. A high performance sealed cell with Planté positive plates and pasted grid negative plates, separated by ribbed diaphragms of microporous Porvic, it is specially designed for trickle-charge operation. It is therefore the ideal cell for all stand-by applications, including emergency lighting in hospitals, cinemas, theatres and public buildings of all kinds, and auxiliary duties in both nuclear and conventional power stations. The design of the cell results in a lower internal resistance and therefore provides a very much improved high rate performance, making it eminently suitable for switch-operating duties where high rates of discharge are involved. With the great reduction of space required, and the renowned reliability and long life of its predecessors, this new Tudor high-performance cell marks a great step forward in stationary battery design.

THE IMPROVED SAFETYLYTE EMERGENCY LIGHTING EQUIPMENT

Tudor Safetylyte equipments are now being fitted with the new stationary cell. Charge and control cubicles are of improved design – the larger equipments being of folded sheet steel, and the smaller specially constructed for wall-mounting, employing automatic mercury relay in place of a contactor.



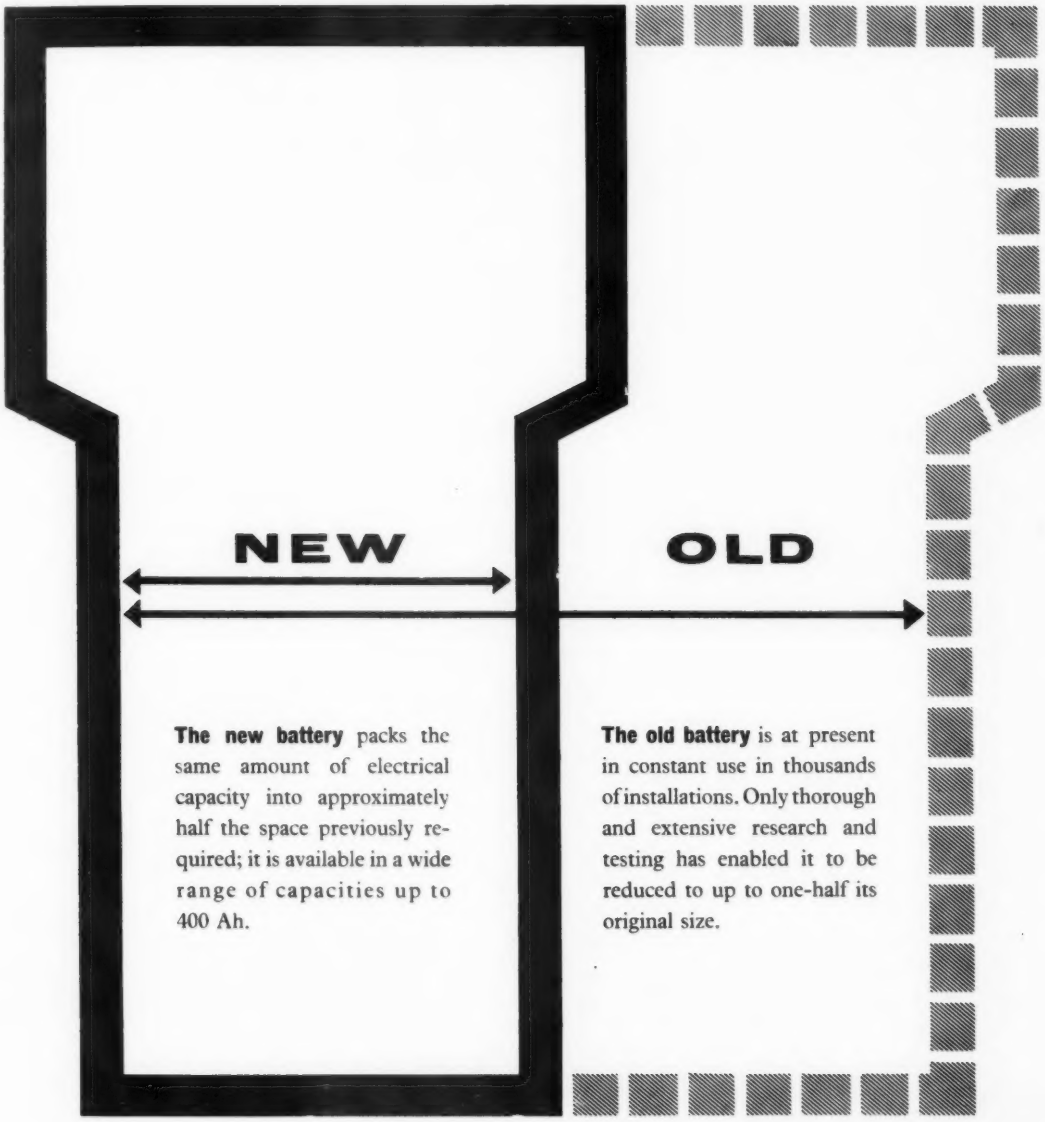
THE NEW SWITCH-TRIPPING EQUIPMENT

Tudor switch-tripping units will in future be fitted with the new cell. The cubicles have also been redesigned, and are available in folded sheet steel or wooden cabinet construction. The charger can now be used for both trickle and quick charging.

Tudor **TUDOR**

THE D.P. BATTERY CO. LTD., MAKERS OF KATHANODE AND TUDOR BATTERIES,

REDUCED BY HALF



The new battery packs the same amount of electrical capacity into approximately half the space previously required; it is available in a wide range of capacities up to 400 Ah.

The old battery is at present in constant use in thousands of installations. Only thorough and extensive research and testing has enabled it to be reduced to up to one-half its original size.

BATTERIES

T173

BAKEWELL, DERBYSHIRE. TELEPHONE BAKEWELL 581-5

INSTRUMENTATION

keeps in step with nucleonic needs

MONITORS

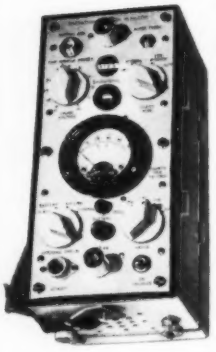
RADIATION MONITOR *Type 1021 B*

- ★ **SAFEGUARDS against contamination.**
- ★ **TRACES radio-active material in chemical analytic processes.**
- ★ **MEASURES contamination of any resulting effluent.**

Designed in conjunction with A.E.R.E. Harwell, this instrument is probably the most widely used general purpose monitor in the world. It has been PROVED by years of user experience to be the most accurate and reliable equipment of its type.

The Radiation Monitor consists of a mains operated Indicator Unit together with a Beta Gamma or Alpha Probe Unit. Indication is provided visually by means of a meter which is calibrated in counts per second, and audibly by means of a loudspeaker. A socket on the front panel is also provided to enable the output to be fed to a scaling unit.

Write for descriptive leaflet No. 26D giving full details.



RADIATION MONITOR *Type 255*

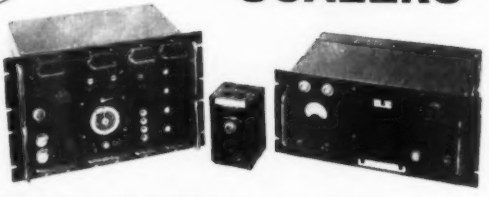
- ★ **Transistorised, battery operated, portable.**
- ★ **Laboratory accuracy under field conditions.**
- ★ **Wide range of probes and accessories available.**

Airmec are proud to be the first to announce a fully transistorised monitor which combines laboratory accuracy with complete portability. The uses include:

1. Checking the presence and amount of radio-active contamination in laboratories and workshops.
2. Checking atmosphere 'fall-out' and contamination of food, animals, crops, milk and water supplies, etc.
3. Following the progress of radio-active tracer elements in medical, geological, agricultural and industrial processes.
4. Tracing the whereabouts of radio-active areas and making accurate assays of samples in geological surveys.
5. Tracing lost samples of radio-active materials both in buildings and out.

Write for descriptive leaflet No. 177

SCALERS



GENERAL PURPOSE COUNTER *Type 1339 A*

- ★ **Designed and developed in conjunction with U.K.A.E.R.E.**
- ★ **Provides comprehensive scaling facilities for all types of Geiger Scintillation Counters.**
- ★ **Incorporates stabilised E.H.T. supplies.**
- ★ **Fitted with automatic timing control.**

This equipment is built on a unit basis and provides very comprehensive scaling facilities for all types of accurate assay work. It consists of two main units — a Power Unit and a Scaling Unit — together with a number of optional sub-units. These include a Quenching Unit, a High Speed Scaling Unit, an Amplifier/Discriminator Unit, a Paralysis Unit and a Timing Unit.

Full details are given in descriptive leaflet No. 185

Airmec

INSTRUMENTS FOR THE NUCLEONIC INDUSTRY

AIRMEC LIMITED · HIGH WYCOMBE
BUCKS

Telephone : High Wycombe 2060

Getting in touch with

ASSOCIATED LEAD

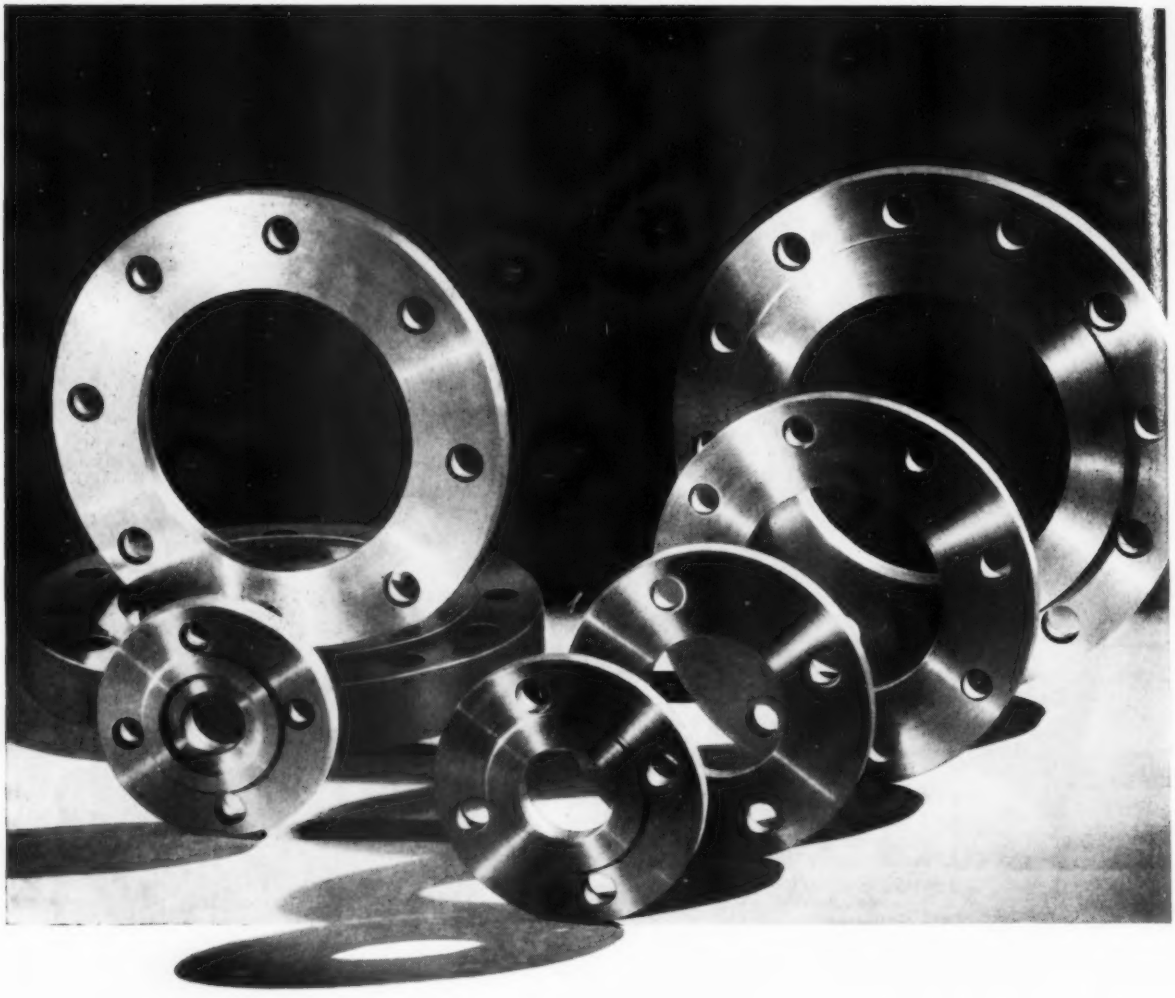
usually leads to better things

No matter how you do it, no matter what your particular industrial need, getting in touch with Associated Lead is bound to lead to better things—better products, better processes—for you and your industry.
Associated Lead Manufacturers Limited is a single company specialising in the manufacture and supply of lead and antimony in all their many forms; alloys; pure metals; chemicals and pigments.

ASSOCIATED LEAD MANUFACTURERS LIMITED CLEMENTS HOUSE, 14 GRESHAM STREET, LONDON, E.C.2.
CRESCENT HOUSE, NEWCASTLE. LEAD WORKS LANE, CHESTER.

Export enquiries to: Associated Lead Manufacturers Export Co. Ltd.. Clements House, 14 Gresham Street, London. E.C.2.

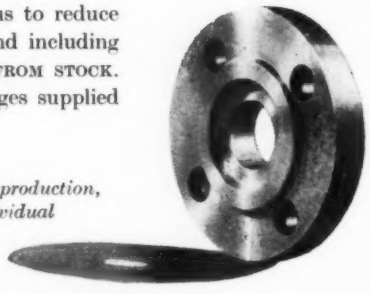
Tick **No 21** on reply card for further details



THE SAME HIGH STANDARD

but cost is lower

New methods and improved production facilities have enabled us to reduce prices of Mild Steel Plate Type Flanges. A full range, up to and including 6" N/B size, for pressures of 50 p.s.i. to 450 p.s.i., AVAILABLE FROM STOCK. Flanges also manufactured to customers' specification. All Flanges supplied with Rust-resistant coating. Full details available on request.

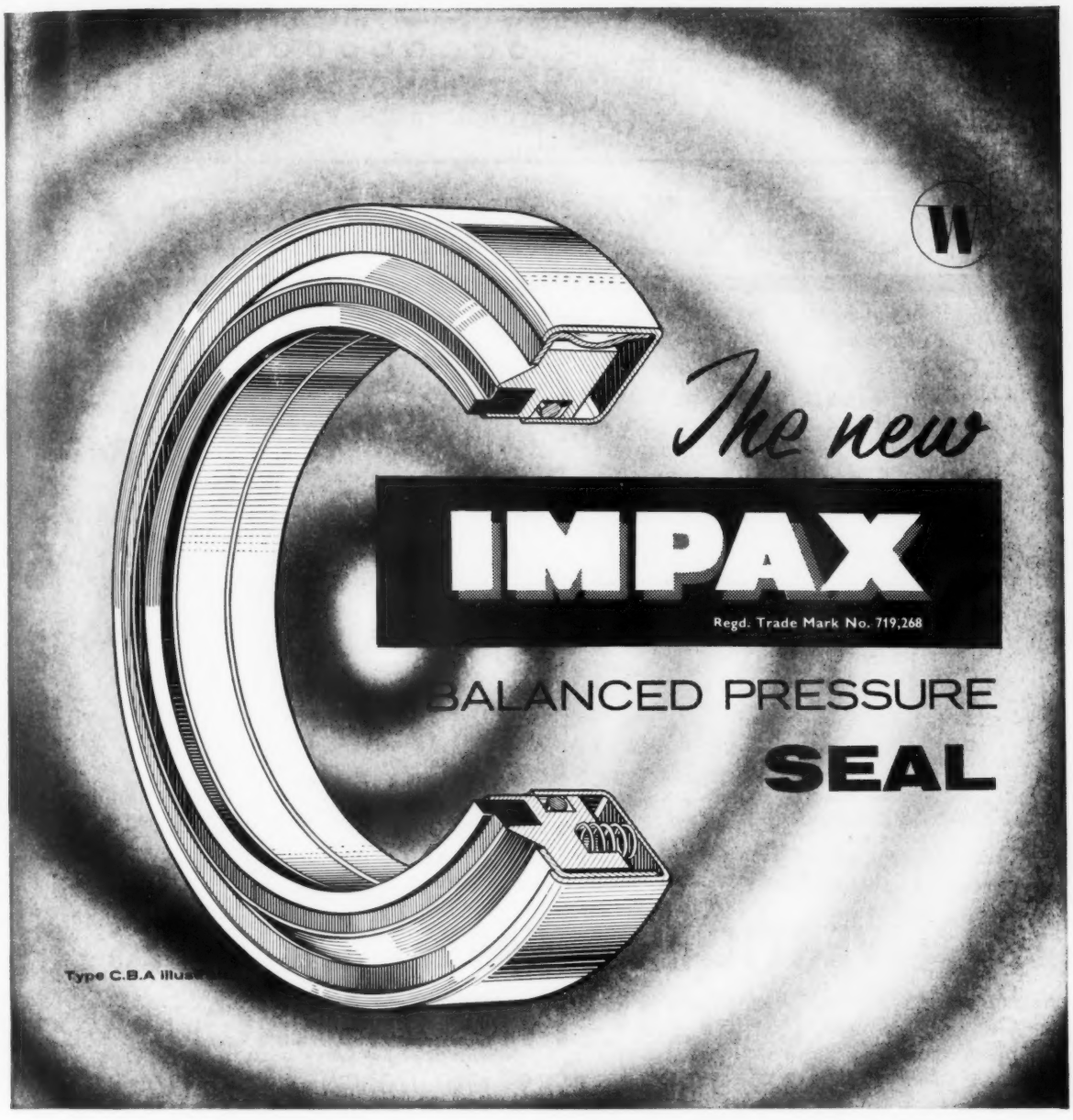


HARVEY MACHINE SHOP FACILITIES: In addition to Flange production, we have an extensive machine shop section for machining and fitting individual items or complete assemblies and machines; together with facilities for grinding (cylindrical and surface), fabrication and stress-relieving.

HARVEY MILD STEEL PLATE TYPE FLANGES

G. A. HARVEY & CO. (LONDON) LTD., WOOLWICH ROAD, LONDON, S.E.7. Telephone: GREenwich 3232 (22 lines)

E/2



FOR SHAFTS ROTATING AT HIGH SPEEDS

Ensure 100% OCCLUSION. Specially designed and produced for the purpose – Weston IMPAX Seals are established for use on high speed rotating shafts, coupled with high fluid temperatures and pressures. A new series has been developed, using the most advanced materials to keep pace with the quickening tempo of modern machine operation.

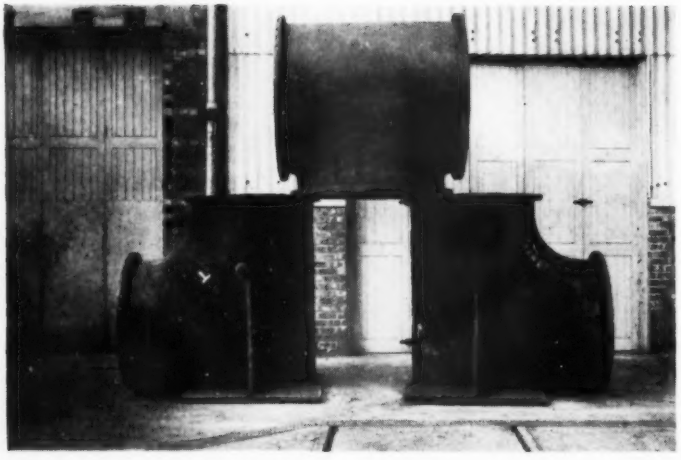
Send for new Catalogue now to: Complete range of Seals available.

CHARLES WESTON & CO. LTD.

Irwell Bank Works, Douglas Green, Pendleton, Salford, 6

Telephone: Pendleton 2857-8-9. Telex: 66-255 · Birmingham: Erdington 5459 · London: Holborn 0414. Telex: 2-2682

CLAY CROSS



for
water
cooling
and
drainage
systems

VERTICALLY CAST IRON PIPES
SPECIAL PIPE CASTINGS

BENDS, TEES, TAPERS, ETC. UP TO 84" DIAM.

SPUN IRON PIPES

SCREWED SPUN FLANGED

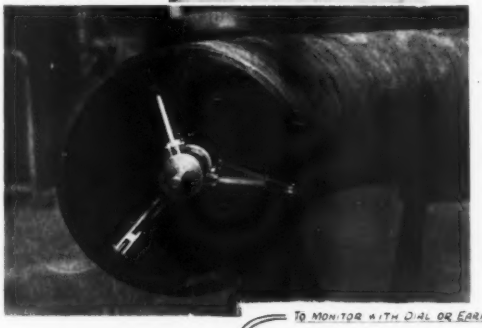
work in progress for the nuclear industry

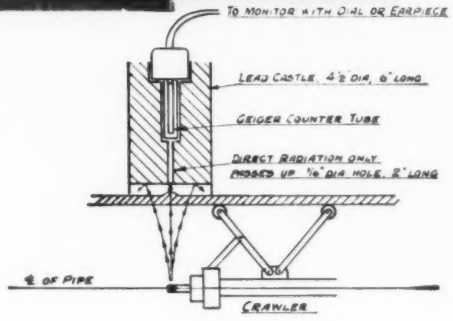
CLAY CROSS (IRON & FOUNDRIES) LTD.

CLAY CROSS, DERBYSHIRE

Telephone: Clay Cross 2151 *Telegrams: Jackson, Clay Cross*

Single-wall radiography made easier




TO MONITOR WITH DIAL OR EARPIECE
LEAD CASTLE 4½ DIA, 6" LONG
GEIGER COUNTER TUBE
DIRECT RADIATION ONLY PASSED UP ½ DIA HOLE, 2" LONG
℄ OF PIPE
CRAWLER

The engineers in the Research and Technical Development Department of Stewarts and Lloyds Limited at Corby had to devise a means of using single-wall radiography for butt welds in pipe lines where the welded joint was 60 feet or more from the open end.

By using a 'crawler' to carry the gamma-ray source along inside the pipe, and a radiation-detecting device on the outside, they were able to establish a procedure that was both quick and simple.

A Geiger counter was placed inside a lead 'castle' on the outside of the pipe. A small hole had been bored in the castle, which was so placed that the hole was immediately on the centre line of the weld. Radiation from the isotope could not reach the Geiger counter except through this hole, so it was easy to determine when the isotope was correctly aligned.

The first photograph shows the crawler and its universal joint, and the second shows the crawler inside the pipe and rounding a bend. The diagram illustrates the locating technique.

We thank Messrs. Stewarts and Lloyds Limited for allowing us to show you this ingenious solution to what appeared to be a very difficult problem.

. . . . . .

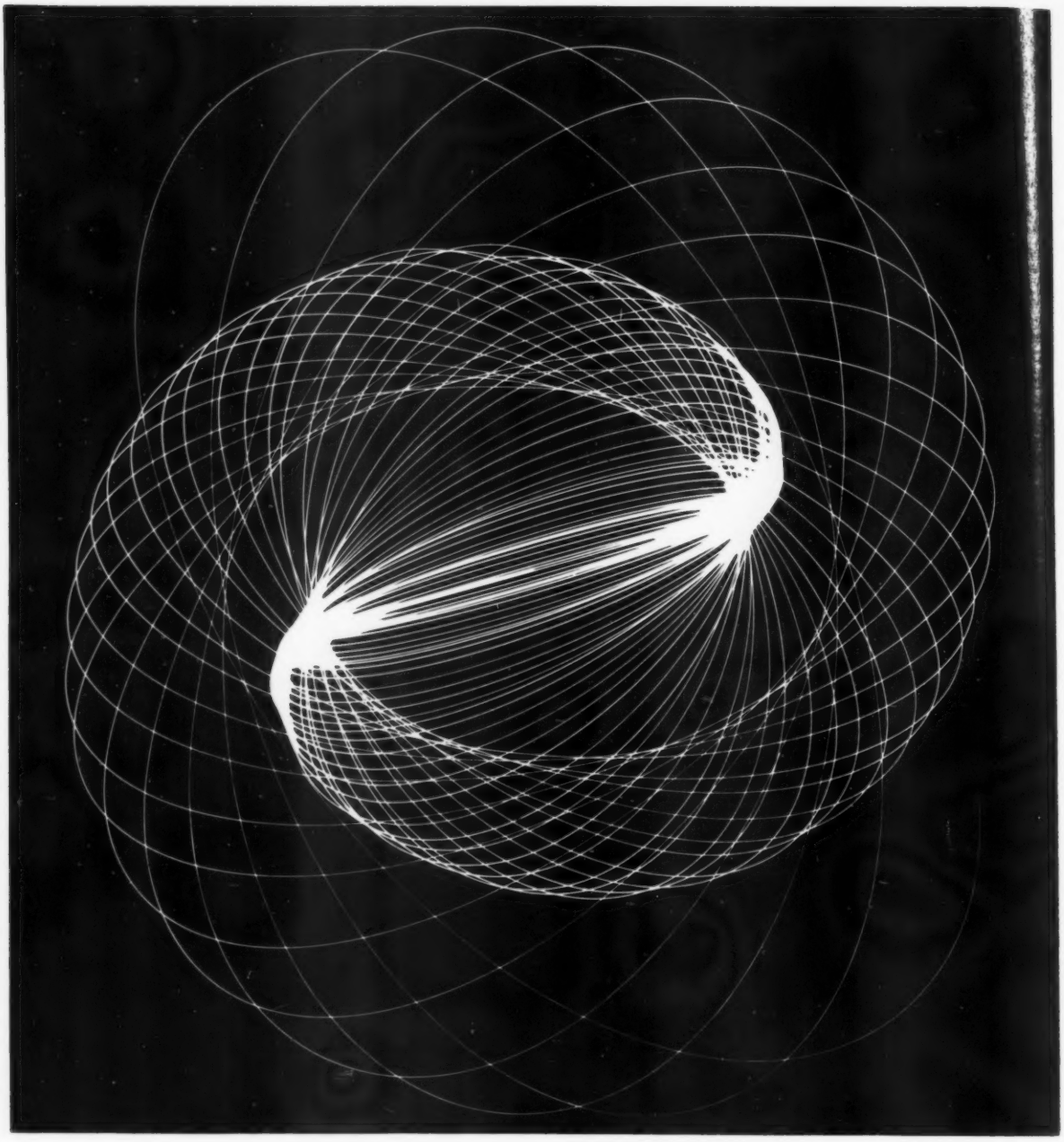
This is one of a series of case histories being published in the technical Press, showing how leading radiologists are finding solutions to their day-to-day problems. They are recounted here in the hope that they will be of interest and value to readers having similar problems.

There is no problem in choosing the right film for a particular job. Kodak make five kinds of industrial X-ray film, covering every requirement from finest resolution to highest speed.

Kodak Industrial X-ray Films

— first choice of inspection engineers everywhere

Kodak Limited,
Industrial Sales Division,
Kodak House, Kingsway, London, W.C.2



If you have a Nuclear Development or Production problem contact us today

GRAVINER

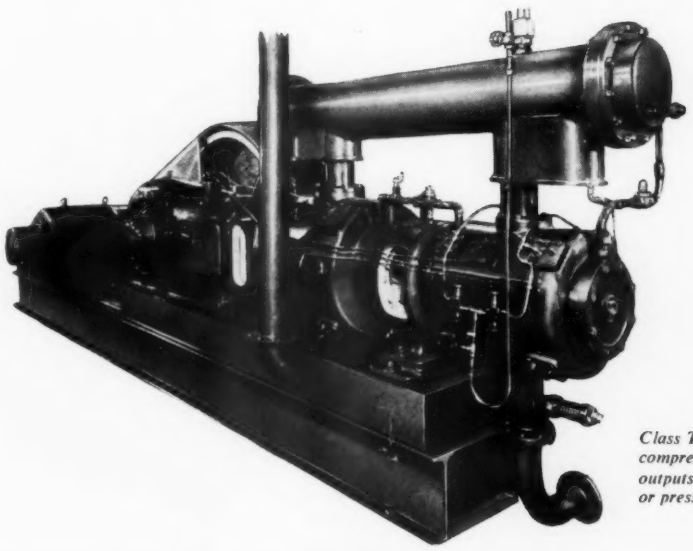
Contractors to The Atomic Energy Authority

FAREHAM ROAD · GOSPORT · HAMPSHIRE
Telephone Fareham 2511

Also specialists in Airborne, Diesel Engine and Industrial Fire and Explosion Protection, Thermostats and Overheat Switches

Choose slow-running class T compressors for long life

It is probably the dream of every plant engineer that each piece of equipment and machinery under his control should operate throughout its life, with no more than "oil-can" attention. This, of course, is often only a dream, but it becomes reality with a plant such as the Class T horizontal, double-acting, water-cooled, stationary compressor. This unit, running at slow speed with efficient lubrication will operate day in and day out for a lifetime, with only the simplest of routine attention. Even this is still more simplified by the design which places all inspection parts at working height. Indeed, the Class T compressor is a machine all plant engineers should know more about and the fullest details are now given in a liberally-illustrated, new publication available free on request.



Class T two-stage, double acting compressors are designed for outputs up to 745 c.f.m. at 100 p.s.i. or pressures up to 2,500 p.s.i.

Consolidated Pneumatic

CONSOLIDATED PNEUMATIC TOOL CO. LTD · DAWES ROAD · LONDON S.W.6

MAKERS OF AIR COMPRESSORS AND 480 DIFFERENT MODELS OF POWER TOOLS

CP. 175 A

You can build any design of case, rack, console or cabinet you like, in any quantity you like, or have them built quickly for you—Imhof's new IMLOK Manual tells you how! 42 pages with full colour illustrations give the whole story: show *every* connector and extrusion in detail: explain exactly what each is used for: give simple step-by-step instructions on how to make IMLOK frameworks, how to fit panels. The IMLOK Manual guides you in designing and using IMLOK and gives a wide range of examples—*which have all been made with IMLOK*. It tells you about finishes and accessories, and even simplifies ordering for you! Always have the new IMLOK Manual by you for designing, constructing and ordering

always have the NEW IMLOK MANUAL by your side

send for your copy NOW

the imlok manual tells all!

Alfred Imhof Ltd., Dept. NIO, Ashley Works, Cowley Mill Road, Uxbridge, Middx. Uxbridge 6231
Export & London Showrooms: 112-116 New Oxford St WC1 Museum 7878

IMHOFS AGENTS OVERSEAS

AUSTRALIA *Aladdin Industries (Pty) Ltd, Stanmore, N.S.W.*
BELGIUM *Rogelec, Ghent*
CANADA *Measurement Engineering Ltd, Arnprior*
DENMARK *Tage Schouboe, Copenhagen N*
FINLAND *Oy Scienta Ab, Helsinki*
HOLLAND *J. Th. van Reijsen, Delft*
NEW ZEALAND *Imarex Ltd, Auckland C3*
NORWAY *Birger Christensen, Oslo*
SWEDEN *Elektronlund AB, Malmo C*
SWITZERLAND *Walter Blum, Zurich 2/39*
U.S.A. *Bud Radio Inc, Cleveland 3, Ohio*
BRIT. GUIANA *British Caribbean Agencies Ltd, Georgetown, Demerara*

CURED IN SIXTY SECONDS

You can be your own doctor when it comes to providing the remedy for a broken or damaged hose-line. The obvious prescription will be AEROQUIP, with its detachable and re-usable end fittings — so easy to fit and so economical to use. If you specify AEROQUIP at birth your brainchild will be relieved of many teething troubles.

Aeroquip

The latest AEROQUIP catalogue will gladly be sent on request.

HOSE LINE AND DETACHABLE, RE-USABLE FITTINGS

SUPER OIL SEALS & GASKETS LTD., FACTORY CENTRE, KINGS NORTON, BIRMINGHAM, 30.

SYNTHETIC RUBBER **fidrac** PRECISION MOULDINGS

POLYTHENE PROTECTIVE **REDCAPS** CAPS AND PLUGS

OIL SEALS AND **SUPERFECT** HYDRAULIC PACKINGS

ROTARY PUMP SEALS **ROMET** WITH MONUM FACES

A Vital contribution to Atomic Power . . .

"WANDLESIDE"

ARMOURED CABLE

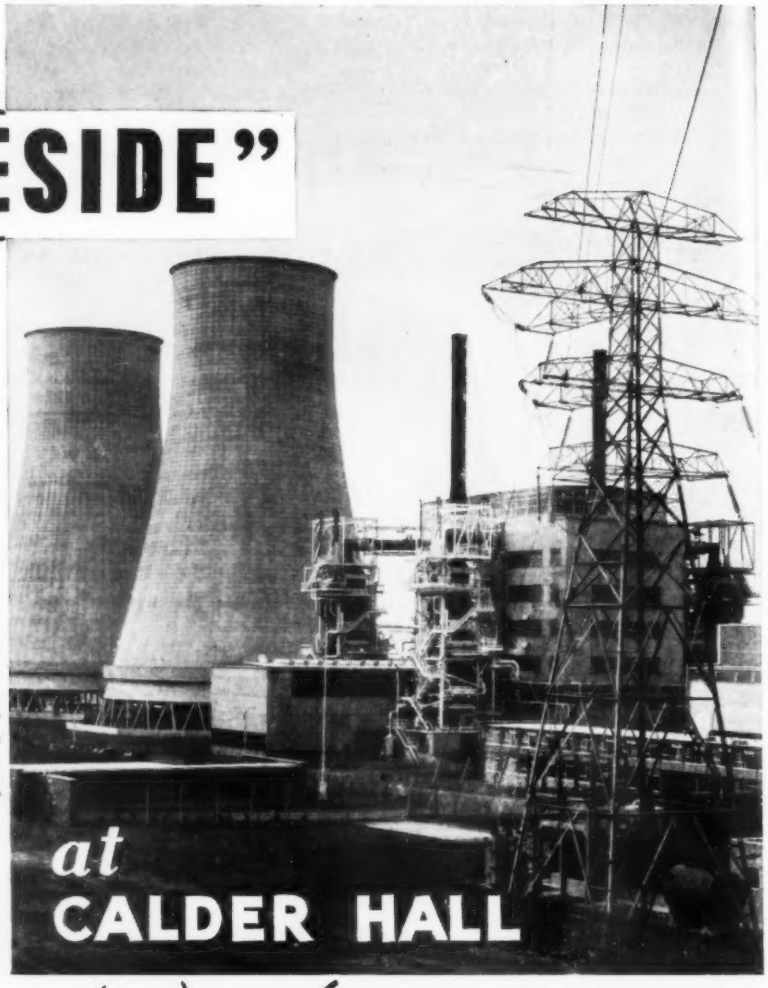


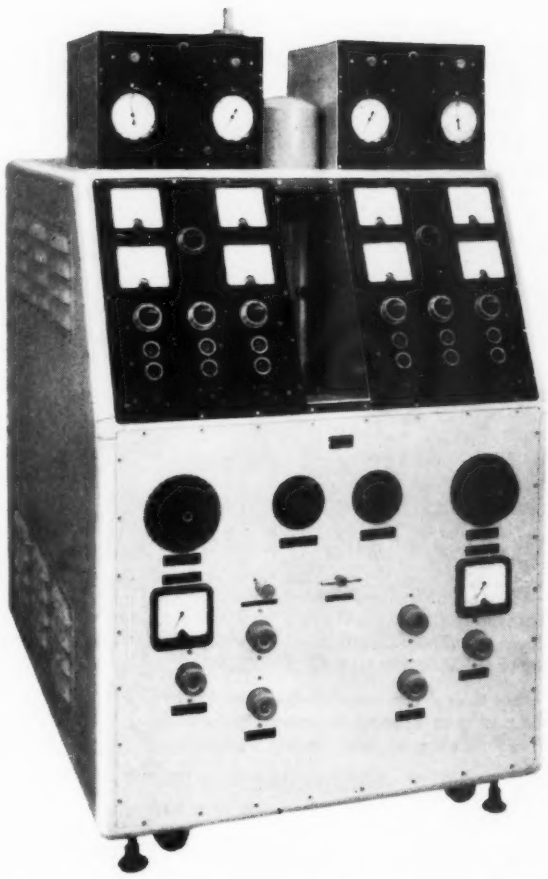
Photo by courtesy U.K. Atomic Energy Authority

With the advancement of Atomic Power, cables must play an important part in the efficiency and reliability in the production of Nuclear Energy. Only the best is good enough and Wandleside Cables are eminently suitable.

WANDLESIDE CABLES *for Nuclear Energy*

WANDLESIDE CABLE WORKS LTD. 106 GARRATT LANE WANDSWORTH LONDON, S.W.18
One of FALKS Group *Telephone: VANdyke 7544 (5 lines)* *Telegrams: Wandleside, London*

Do you require HIGH PURITY Argon?



For the removal of moisture, oxygen and nitrogen. For cleaning up the atmosphere in glove boxes. For welding or for any other application where the need arises to remove one or more of the above impurities.

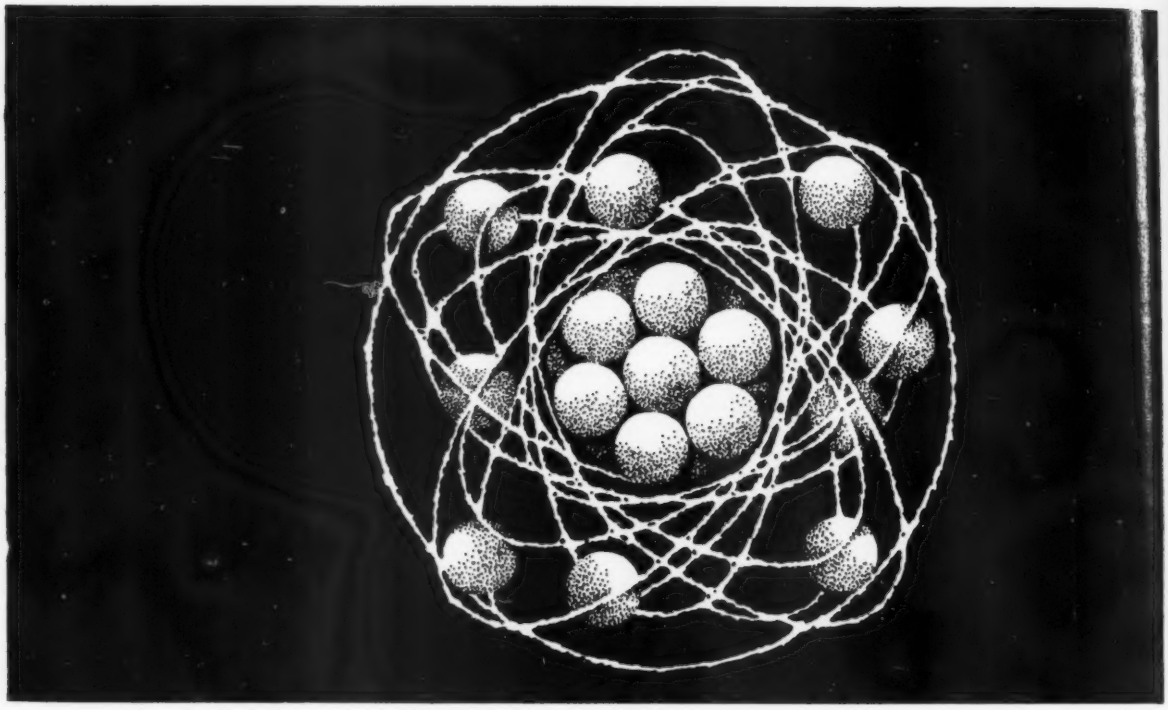
THE MARK IV SELF-CIRCULATING GAS PURIFIER

Supplied in single or in tandem units for long process work. Fully instrumented. Fully automatic

WESTERN DETAIL MANUFACTURERS LTD

WESTERN WORKS, STAPLE HILL, BRISTOL.

Telephone 65-6141/2/3 Telegrams: Aries, Bristol Cables: Aries, Bristol, England



Main CO_2 Duct Isolating Valve for Nuclear Reactor Power Plants for working pressures of 10 kg/cm² and 400° C.

E R H A R D

ABSPERRKLAPPEN (Pat. throughout the world)

The design of the ERHARD-Absperrklappen is not limited to the aforementioned temperatures and pressures, and we are in a position to manufacture valves in order to meet the severest temperature and pressure conditions arising in nuclear reactor power plants.

External means are used in order to urge the disc sealing ring on to or away from the valve seat for closing or opening the valve. Operation can be effected according to requirements by hand, electric, pneumatic and hydraulic means.

For all information write to:

The Sole Agents for the United Kingdom

A. K. STARCK'S CO. LTD.

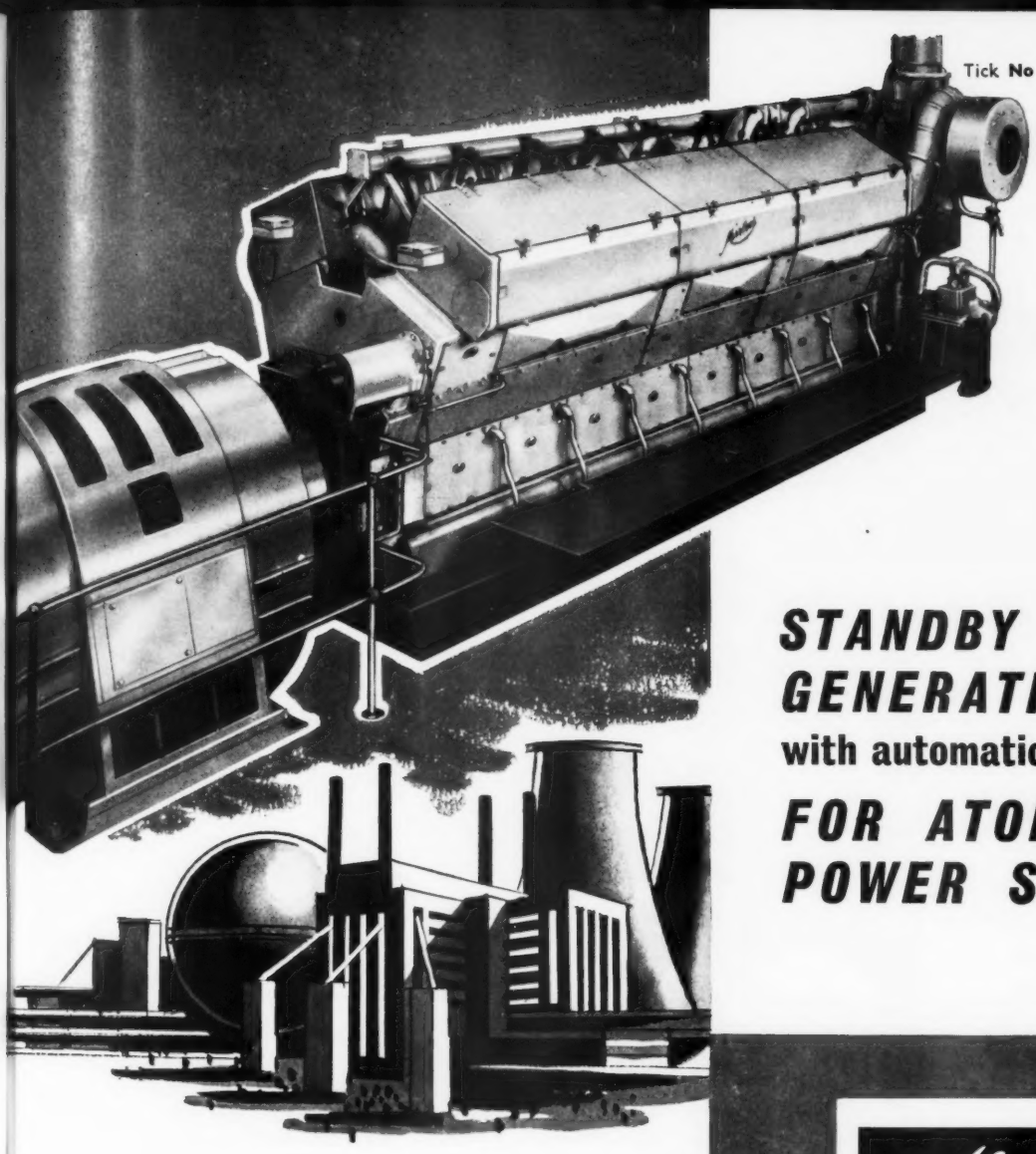
22, Chancery Lane London W.C.2

Telephone Holborn 2966 Cable: Akstar London

JOHANNES ERHARD H. WALDENMAIER ERBEN

Süddeutsche Armaturenfabrik Heidenheim an der Brenz Western-Germany

Tick **No 33** on reply card for further det



STANDBY GENERATING SETS
with automatic starting
FOR ATOMIC POWER STATIONS

Within a few seconds of receiving the starting signal and without manual attendance, these Mirrlees oil-engine sets will carry full load, providing a reliable auxiliary and standby supply for atomic power stations and other installations where it is essential to forestall breakdowns and serious loss due to cessation of mains power supply. The Mirrlees J and JV Types of engine cover a comprehensive series including 3, 4, 5, 6 and 8-cylinder in-line engines and 12 and 16-cylinder vee-form engines. All can be offered in naturally aspirated or turbocharged form, the latter with or without air aftercoolers.

Mirrlees diesels

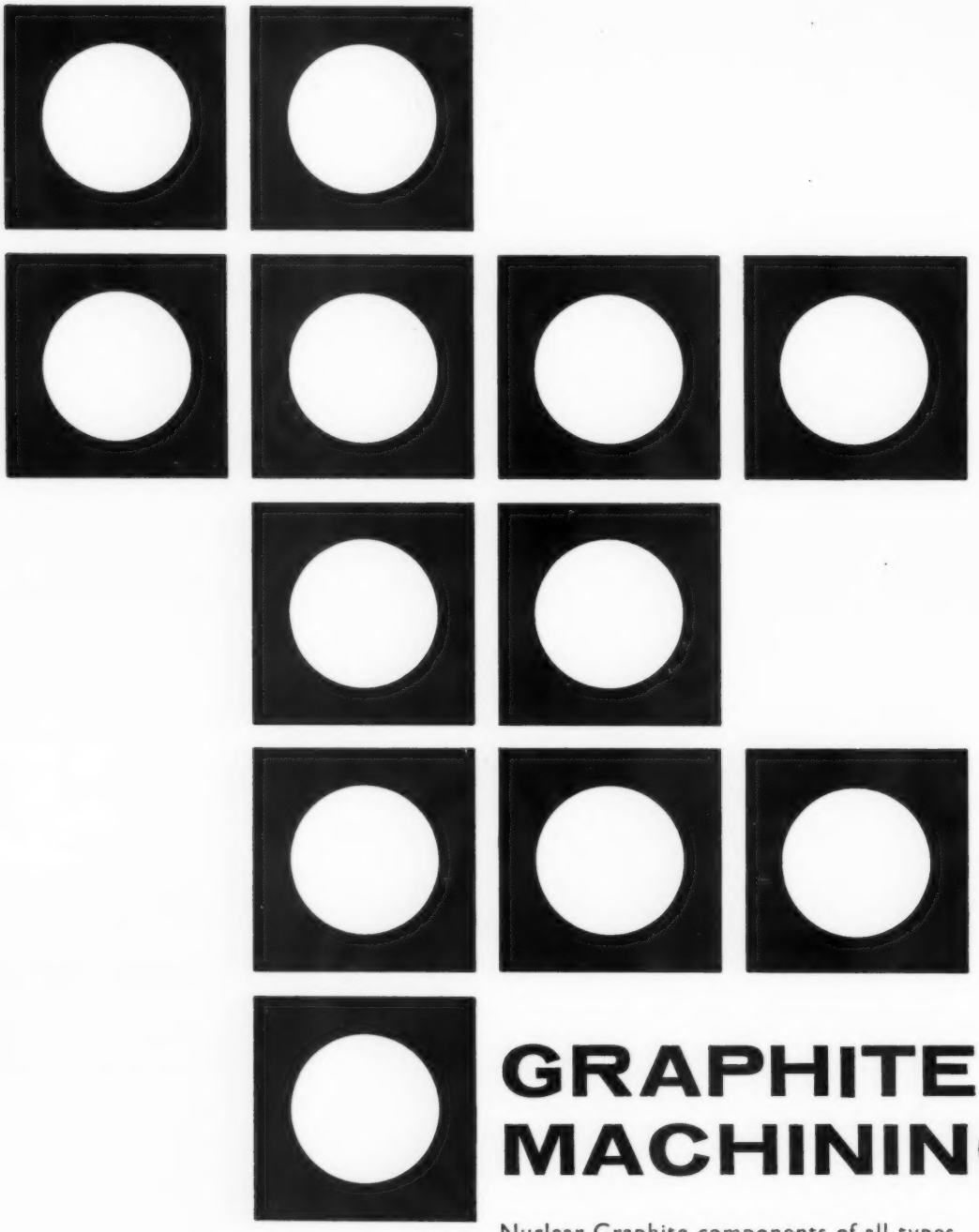
The power range extends from the 210 BHP J3 three-cylinder naturally aspirated up to the 2272 BHP JVSS 16 sixteen-cylinder turbocharged engine with air aftercooler.

MIRRLEES, BICKERTON AND DAY LIMITED
HAZEL GROVE · STOCKPORT · CHESHIRE

A member of the HAWKER-SIDDELEY Group

Telephone: Stepping Hill 1000 (14 lines) Telegrams: "Mirrlees Telex, Manchester"

IE



GRAPHITE MACHINING

Nuclear Graphite components of all types for atomic energy purposes machined under clean conditions.
Bulk deliveries now in progress to Hunterston and other Nuclear Power stations.

THE POWELL DUFFRYN GROUP OF COMPANIES

POWELL DUFFRYN CARBON PRODUCTS LTD.,
NUCLEAR GRAPHITE DIVISION
Springfield Road, Hayes, Middlesex. Telephone Hayes 3994

Formula for cost reduction

'SOCAST' STEEL CASTINGS

BY PRECISION METHODS

An increasing number of manufacturers of plant are using components cast by precision methods. In many instances, components previously machined from the solid are being produced as castings with marked economies.

Intricate designs may be cast in stainless and many other steels to close tolerances, with good surface finish and freedom from porosity. Machining allowances are drastically reduced, and often eliminated.

Reduce *your* manufacturing costs and expedite production by high quality *'SOCAST'* steel castings, which will withstand high pressures and avoid many repairs and rectifications in the machine shop.

FINE STEELMAKERS · STEEL FOUNDERS
ENGINEERS' TOOLMAKERS

OSBORN

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS SHEFFIELD

The silhouettes of the atomic power stations, strange and new a year or two ago, are today familiar to technical men.

Keeping pace with new developments for over 75 years, 'Tornado' fan engineering equipment now finds itself quite at home in these strange landscapes, assisting in the exacting work of the UKAEA establishments. Among the equipment we have supplied for Dounreay is fan equipment for the vessel ventilation system, the Highly Active Liquor Store and the Billet Production Plant.

In addition, equipment has been installed at Aldermaston, Capenhurst, Foulness, Harwell, Risley, Springfields and Windscale and other Keith Blackman fans and blowers are being used experimentally elsewhere. If the problem involves the handling of air or other gases, contact

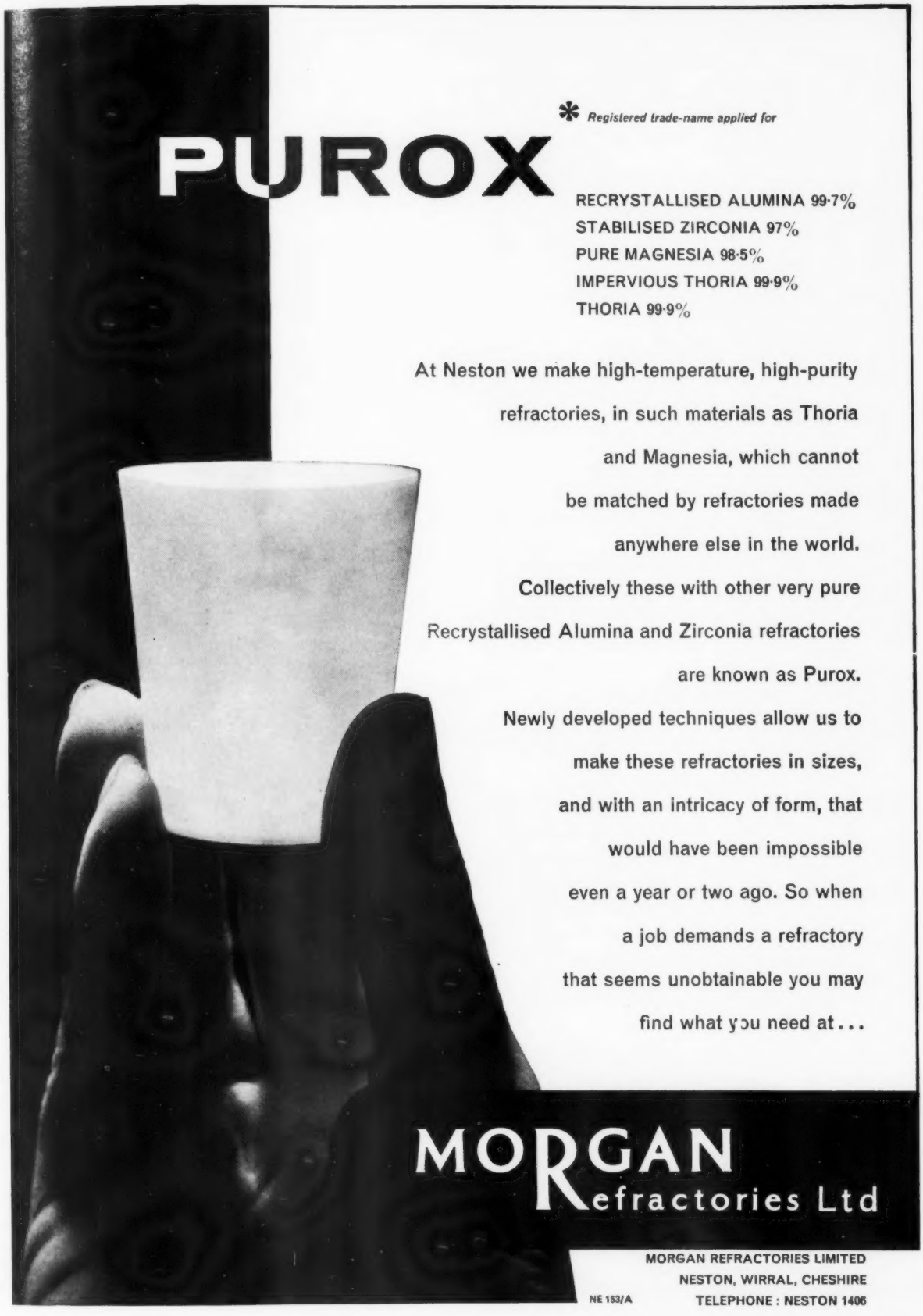
Keith Blackman Ltd

MILL MEAD ROAD LONDON N17

BIRMINGHAM · BRISTOL · GLASGOW · LEEDS · LEICESTER · MANCHESTER · NEWCASTLE

'Tornado' equipment includes: CO_2 Coolant Blowers and Heat Exchanger Cooling Fans. Fans for Ventilation, Dust Removal and High Temperature Extraction. Blowers for Gas Boosting, Dry Scrubbers and Vessel Ventilation. Also Air Sampling Compressors, Air Flow Control Units, Back Pressure Valves, Steel Fabrications and the Keith Blackman-Broman Ekstrom Shot Cleaning of Heat Exchangers.

TA2315/988



PUROX*

*Registered trade-name applied for

RECRYSTALLISED ALUMINA 99·7%
STABILISED ZIRCONIA 97%
PURE MAGNESIA 98·5%
IMPERVIOUS THORIA 99·9%
THORIA 99·9%

At Neston we make high-temperature, high-purity refractories, in such materials as Thoria and Magnesia, which cannot be matched by refractories made anywhere else in the world. Collectively these with other very pure Recrystallised Alumina and Zirconia refractories are known as Purox. Newly developed techniques allow us to make these refractories in sizes, and with an intricacy of form, that would have been impossible even a year or two ago. So when a job demands a refractory that seems unobtainable you may find what you need at...

MORGAN Refractories Ltd

MORGAN REFRACTORIES LIMITED
NESTON, WIRRAL, CHESHIRE
TELEPHONE : NESTON 1406

NE 153/A

Tick **No 37** on reply card for further details

AVO INSTRUMENTATION

Regd. Trade Mark

Pioneers in the design and manufacture of Multi-range Testing Instruments since 1923

AVO instruments are at the service of B.O.A.C. throughout the world

D.C. Amplifiers
Radiation Monitors
Valve Voltmeters
Multi-range Testmeters
Valve Testers
and other electronic and nucleonic instruments

AVO LTD

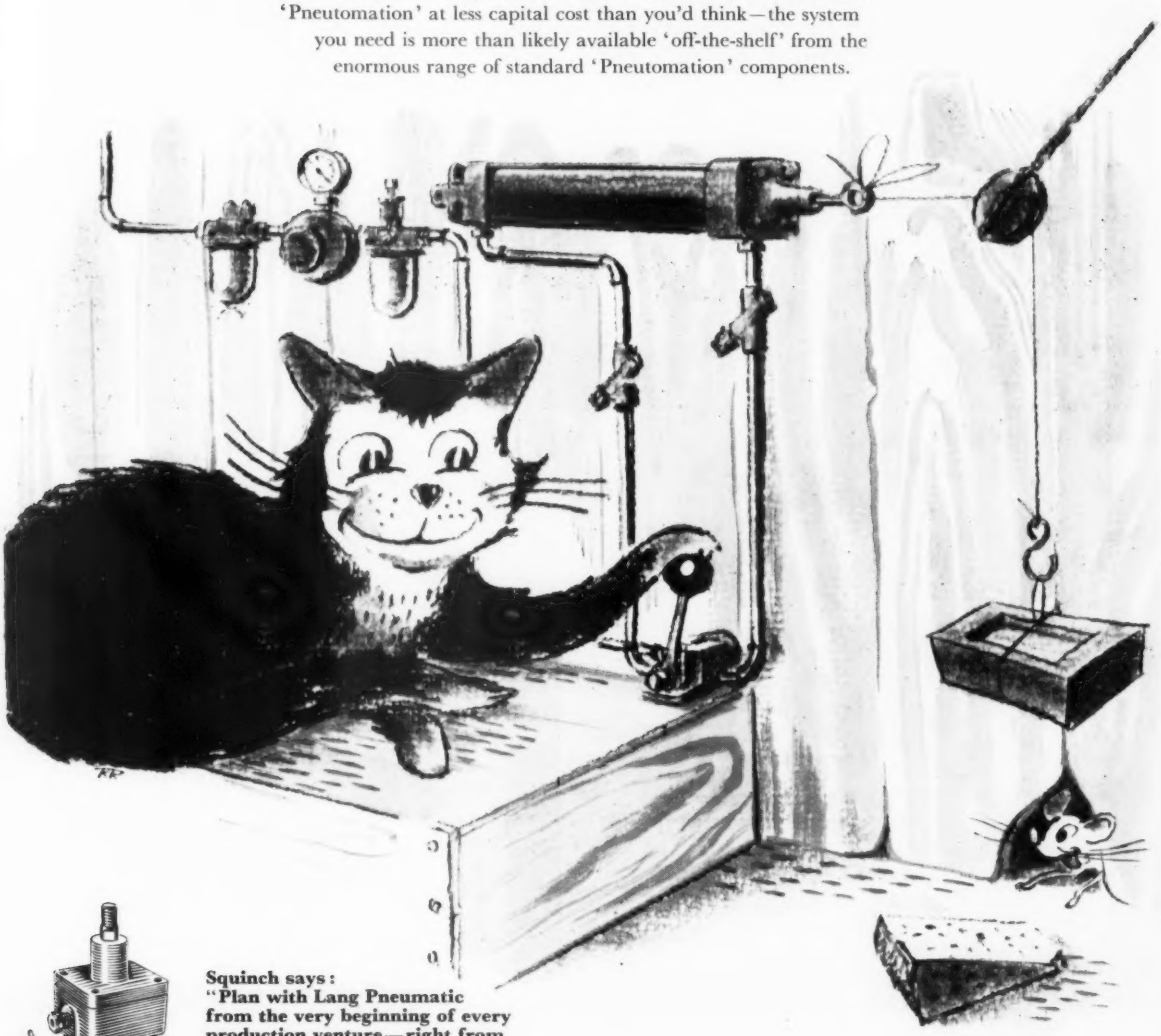
AVOCET HOUSE · 92-96 VAUXHALL BRIDGE ROAD · LONDON · S.W.1

Telephone: VICtoria 3404 (12 lines) *Cables: Avocet, Sowest, London*

G21

PNEUTOMATION

There's a 'situation vacant' in every firm for the tough, willing worker who never tires, never makes an error, will tackle anything—in short, 'Pneutomation'. 'Pneutomation'—Lang Pneumatic air-power systems—is the guiding hand behind a host of jobs from jig-boring to bell-ringing, providing accurate, low-cost control of complex or simple operations. You can enjoy the benefits of 'Pneutomation' at less capital cost than you'd think—the system you need is more than likely available 'off-the-shelf' from the enormous range of standard 'Pneutomation' components.



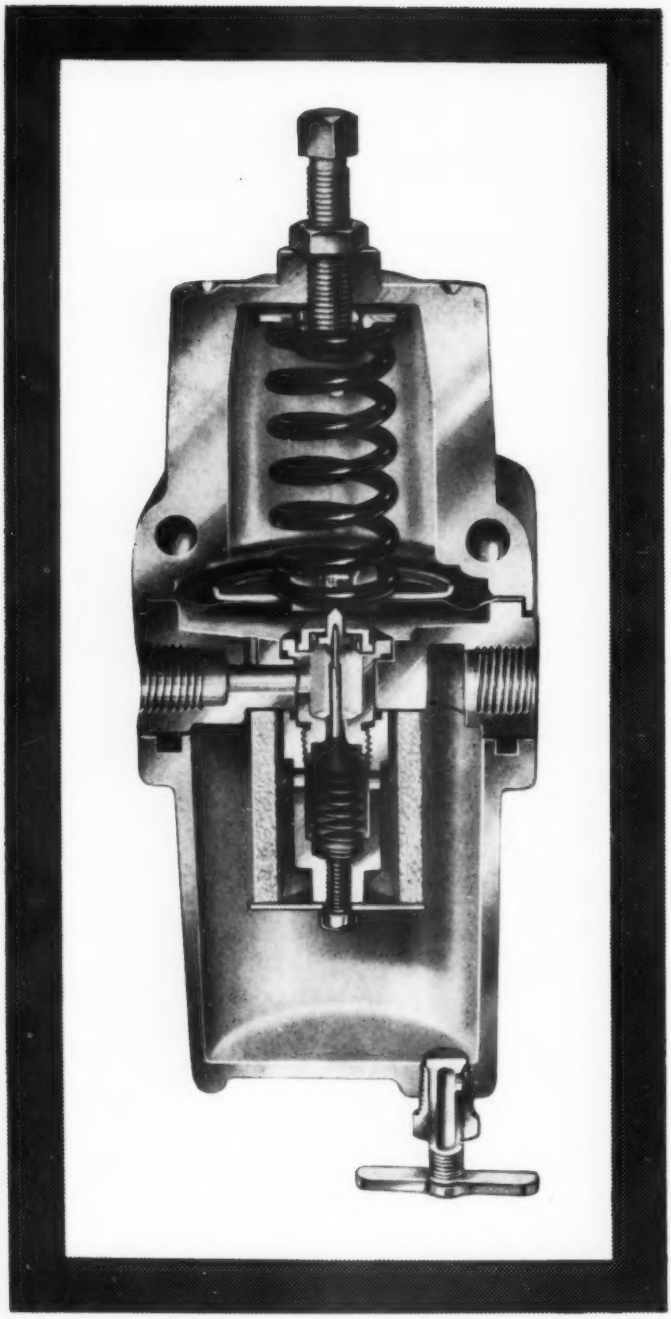
Squinch says:
"Plan with Lang Pneumatic from the very beginning of every production venture—right from the start, you'll be certain of the happy ending!"

Write to:

Lang Pneumatic Ltd

[ASSOCIATED WITH DESOUTTER BROTHERS (HOLDINGS) LTD.]
OWEN ROAD, WOLVERHAMPTON *Telephone Wolverhampton 25221-2-3-4*

P3429

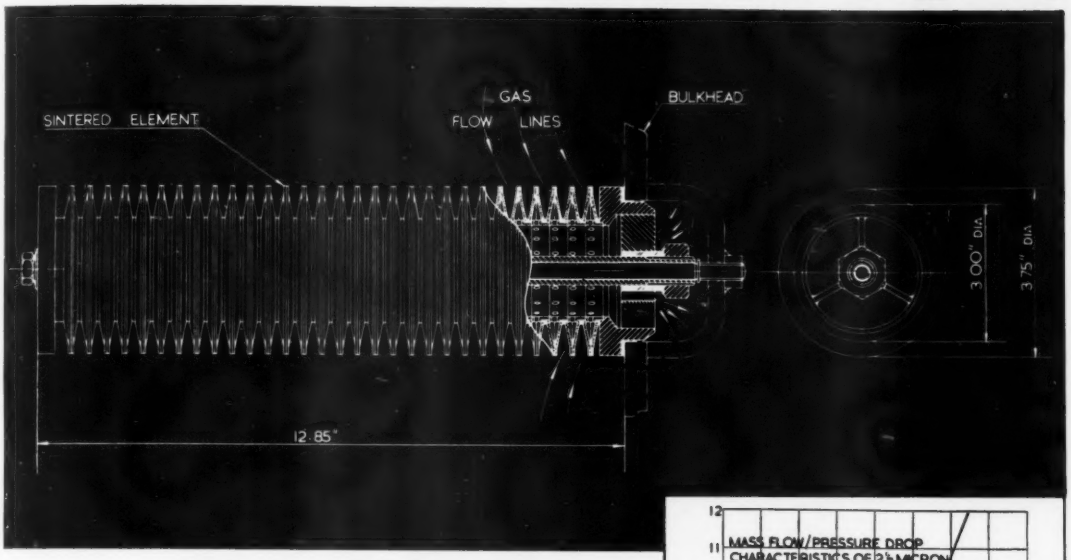


New MASONEILAN improved low priced No. 77 air filter regulator set

* Combined dripwell — filter — reducing valve — relief valve
* Exceptionally flat pressure flow characteristics
* Corrosion resisting diecast aluminium body: stainless steel and brass working parts
* Compact — lightweight — easy to maintain

CROSBY VALVE & ENGINEERING CO. LTD. · WEMBLEY · MIDDLESEX · ALPerton 2311

GAS FILTRATION



BY FAIREY

GUARANTEED POSITIVE FILTRATION
TO 5 OR 2½ MICRONS

MAXIMUM FLOW AREA FOR MINIMUM OVERALL BULK
(375 sq. ins. for the filter shown)

LOW INSTALLATION COSTS

EASILY CLEANED

ROBUST CONSTRUCTION

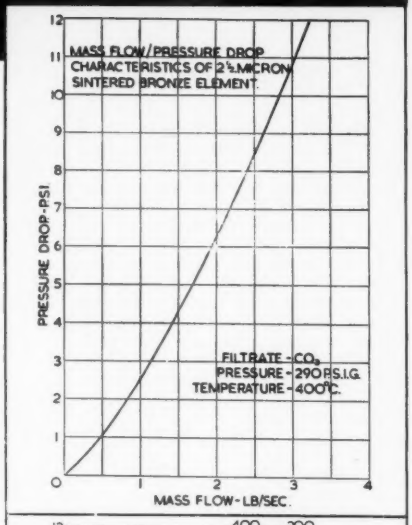
FREEDOM FROM THERMAL SHOCK PROBLEMS

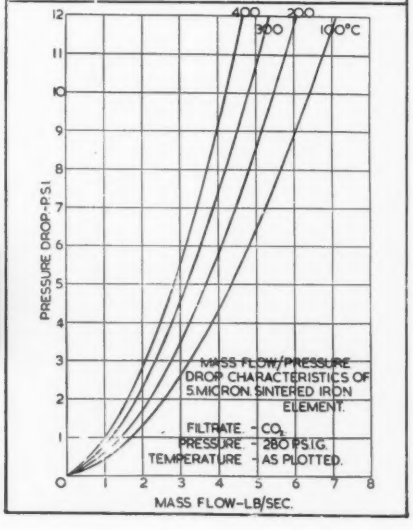
Fairey gas filtration will be used in the new nuclear power station at Trawsfynydd, North Wales.

Further details on request

FAIREY AVIATION LIMITED
Hydraulics Division, Hayes, Middlesex

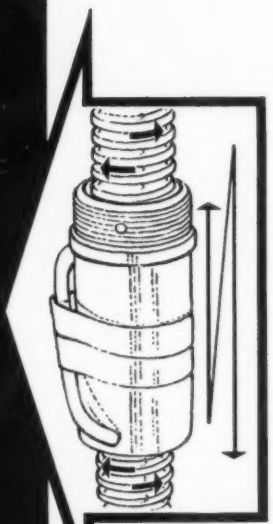
A subsidiary of The Fairey Company Limited


MASS FLOW/PRESSURE DROP CHARACTERISTICS OF 2½ MICRON SINTERED BRONZE ELEMENT.
FILTRATE - CO_2
PRESSURE - 290 P.S.I.G.
TEMPERATURE - 400°C.
PRESSURE DROP - P.S.I.
MASS FLOW - LB/SEC.



Tick **No 41** on reply card for further details

Bristol Siddeley provide a comprehensive range of high precision recirculating ball and lead screws and splines for universal applications.



HIGH EFFICIENCY

BACK-LASH ELIMINATION

LONG LIFE

LOW MAINTENANCE FACTOR

Up to 80% reduction in power can be achieved for actuation compared with conventional methods.
Ability to run at high temperatures with and without lubrication.
Over 2,700 applications already established in all fields of engineering.
Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.

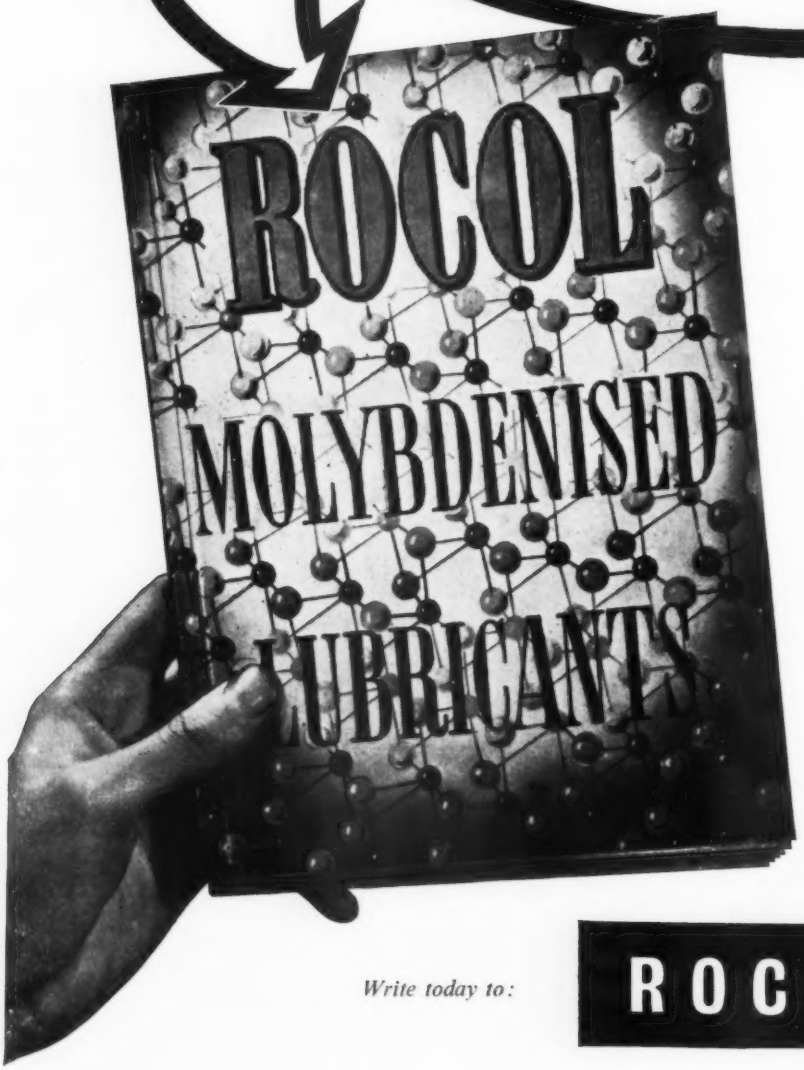
BRISTOL SIDDELEY ENGINES LIMITED
COVENTRY · ENGLAND

Lead shielding of a complicated nature is being
successfully produced to Harwell design by
R. E. Roberts & Son Limited, Bolton,
for the U.K.A.E.A., Risley, and for private companies engaged
in the development of nuclear power.

R. E. ROBERTS & SON LTD., WINDLEY STREET, BOLTON, LANCASHIRE FC A MEMBER OF THE FIRTH CLEVELAND GROUP

CRC 7R

Read all about Molybdenised Lubricants in this FREE BOOK



The most comprehensive treatise on Molybdenum Disulphide Lubrication yet published, this book can be of great value to you,

Write today to:

ROCOL LTD

GENERAL BUILDINGS, ALDWYCH, W.C.2 *Telephone: HOLborn 1985*

ROCOL HOUSE, SWILLINGTON, Nr. LEEDS *Telephone: Garforth 2261/2*

n.d.h. 3287/A

Special Project

A special project, being the result of special thought, demands a careful choice of materials. The four cooling oil jackets of the R.F. particle accelerator—part of the 7 GeV proton synchrotron sited at the Rutherford High Energy Laboratory, Harwell—have to be structurally strong but non-magnetic. Each has to carry 3,000 lbs of ferrite core in oil at 9 p.s.i.g. The choice was glass cloth/epoxy resin laminates moulded by Marston.
Marston's experience proves that reinforced plastics, used appropriately, are better, cheaper and weight-for-weight stronger than equivalent constructions in metal. And they combine resistance to fire and corrosion with electrical and thermal insulation.

Reinforced plastics could solve your design problem —why not consult us now ?

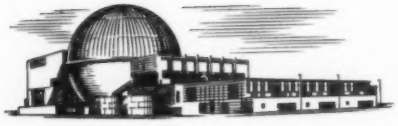
MARSTON EXCELSIOR LTD
(A subsidiary company of Imperial Chemical Industries Limited)
FORDHOUSES, WOLVERHAMPTON

MAR.271

Tick **No 45** on reply card for further details

BY APPOINTMENT TO HER MAJESTY THE QUEEN
Suppliers of Fire Extinguishers *The Pyrene Company Limited*

facing new fire problems in the sphere of nuclear power



The Pyrene Company, with its unrivalled facilities for research, keeps ahead of changing industrial techniques, and is constantly developing the means to overcome the new fire risks they involve. As makers of the world's most comprehensive range of fire-fighting equipment, The Pyrene Company can give you invaluable and impartial advice on any fire protection problem—it is yours for the asking.

We are proud to have given advice on fire protection—and supplied major fire-fighting equipment—for most British atomic centres already constructed. Consult Pyrene Fire Engineers and ensure maximum fire protection for valuable plant and human lives too.

Pyrene TRADE MARK FIRE APPLIANCES

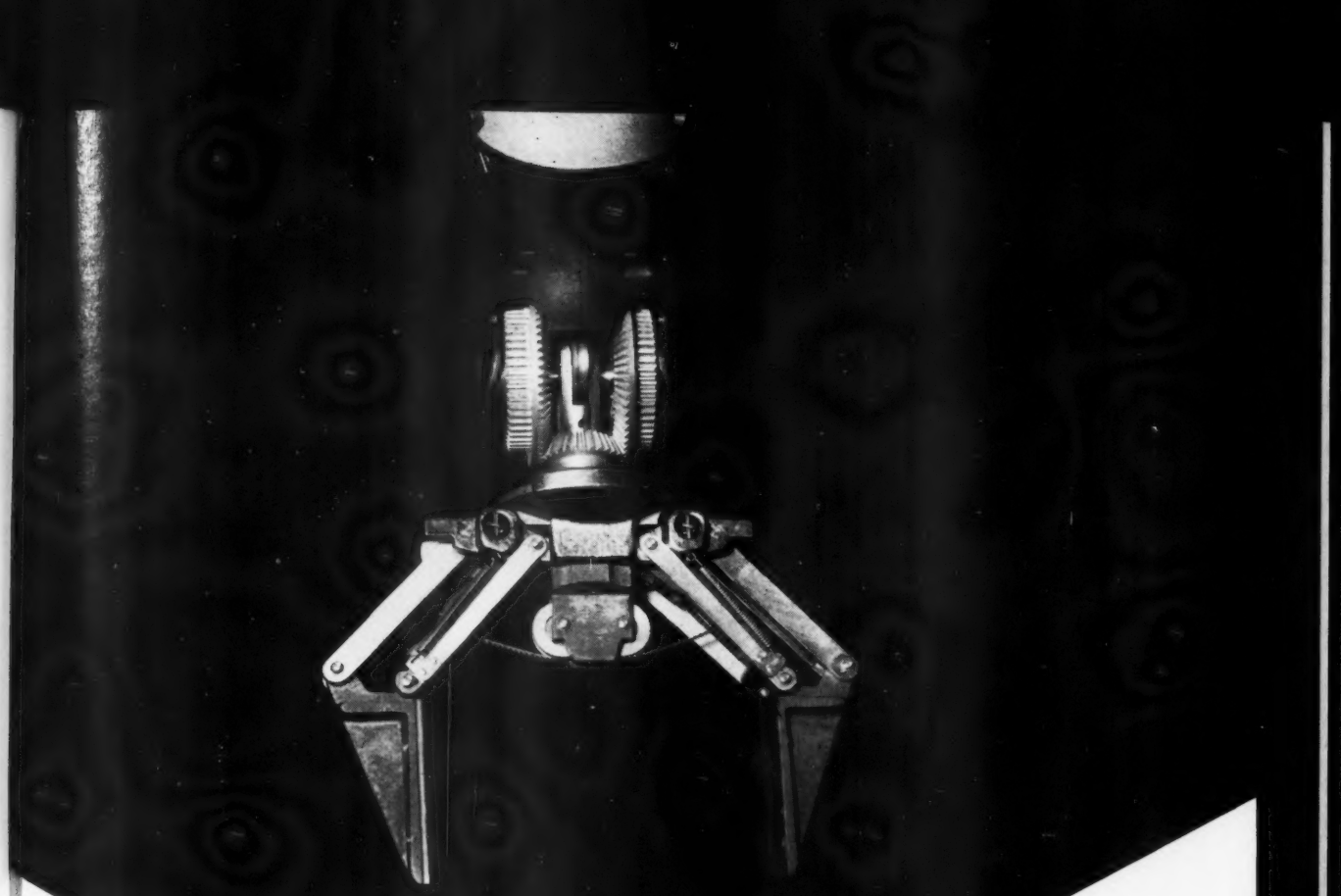
protect
ALDERMASTON
CALDER HALL
CAPENHURST
DOUNREAY · FOULNESS
HARWELL · SPRINGFIELD
WINDSCALE

Pyrene TRADE MARK
FIRE FIGHTING EQUIPMENT

THE PYRENE COMPANY LIMITED

(*Dept. NP 5*) 9 GROSVENOR GARDENS · LONDON S.W.1 *Tel:* VICtoria 3401
Head Office & Works: GREAT WEST ROAD · BRENTFORD · MIDDX
Canadian Plant: TORONTO *Australian Plant:* MELBOURNE

Tick **No 46** on reply card for further details



Manipulators

The manipulators used at atomic establishments have to operate under exacting conditions. They are constructed of stainless steel and Kanigen plated aluminium and the plate serves two functions. It resists corrosion and, because of the smoothness of the finish, it also assists in decontamination of the component parts from radio-active material; and the combination of stainless steel and Kanigen plated aluminium reduces the electro potential difference between the component parts. These manipulators, manufactured by Savage & Parsons Ltd., are supplied to users all over the world. Kanigen is used on the aluminium parts of the Tong End assembly and the Master Hand assembly.

Kanigen

A HARD & CORROSION RESISTANT PLATE

KANIGEN is a nickel-phosphorus plate deposited by chemical reduction: thickness can be controlled to fine limits and is of complete and uniform coverage.

PROPERTIES:

Composition	92% Nickel 8% Phosphorus
Melting point	890°C.
Electrical resistivity	60 microohm cm.
Hardness	500—1,000 V.P.N. according to heat treatment
Coverage	Extremely uniform

Kanigen can be applied to all ferrous metals, aluminium, copper and brass. The plating plant at Oldbury has now been extended, two extra plating tanks are in operation and enquiries for jobbing plating are welcomed. Full information is available on request.

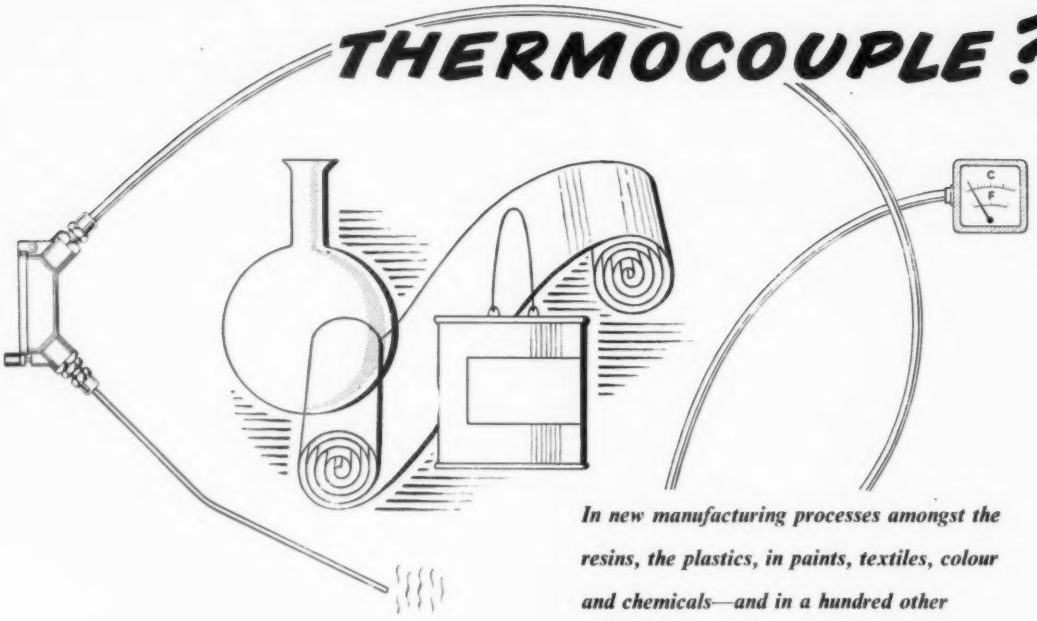
Albright & Wilson
(MFG) LTD
Kanigen Department
1 KNIGHTSBRIDGE GREEN · LONDON SW1

Kanigen is a regd. trademark of Albright & Wilson Ltd

rsw/621

KANIGEN

What do you expect of a THERMOCOUPLE?



In new manufacturing processes amongst the resins, the plastics, in paints, textiles, colour and chemicals—and in a hundred other spheres—temperature control is playing a bigger and more vital part.

Higher accuracies, quicker responses, longer life—these are the demands imposed by today's thermo-instrumentation. And, these too, are the inherent features of 'Pyrotenax' Thermocouples. Add to these the characteristics shown and you have the reasons why 'Pyrotenax' Thermocouples are the considered choice of the scientist and technician behind such projects as Bradwell and Calder Hall etc. and other famous enterprises in Industry.

'Pyrotenax' Thermocouples are supplied with conductors of COPPER/CONSTANTAN with either CUPRO-NICKLE or MILD STEEL sheath, conductors of NICKEL-CHROME NICKEL ALUMINIUM ALLOY with NICKEL-CHROME STEEL sheath for high accuracy, high temperature applications.

Full Technical details in Publication 31/X110

PERFECTED BY EXPERIENCE
Pyrotenax
m.i. THERMOCOUPLES

Use of the name "Pyrotenax" is exclusive to the products of this company and its associates.

✓ **EASILY BENT TO SHAPE**

they are

✓ **IMMUNE FROM THERMAL SHOCK AND MECHANICAL DAMAGE**

their

✓ **SMALL OVERALL DIAMETER**
permits use in restricted spaces allowing simultaneous readings at different points, where normally only one conventional type could be sited, and generally

NO ADDITIONAL PROTECTIVE SHEATHING REQUIRED

✓ *resulting in a*

RAPID RESPONSE RATE

✓ comparable with that of mercury-in-glass thermometer

They have a

✓ **LONG LIFE**

but, because they are

✓ **INEXPENSIVELY REPLACED**
they may be used at temperatures far in excess of those normally permitted for economic operation

PYROTENAX LIMITED HEBBURN-ON-TYNE *Telephone: Hebburn 83-2244/8*

LONDON: *VICtoria 3745* · **BIRMINGHAM:** *Midland 1265* · **MANCHESTER:** *Deansgate 3346/7* · **LEEDS:** *Leeds 27826* · **GLASGOW:** *City 3641/2* · **CARDIFF:** *Cardiff 23689*
GD110

ask SIMA

INSTRUMENT CENTRE

20 QUEEN ANNE STREET, LONDON, W.1

Telephone: IMPerial 6000

(Press enquiries: LANgham 4251)

key to information

and advice on:

- ★ **Electronic and nuclear instruments**
- ★ **Navigational and survey equipment**
- ★ **Optical and ophthalmic instruments**
- ★ **Laboratory, medical and X-ray apparatus**
- ★ **Instruments for process control and automation**
- ★ **Kinematograph and allied instruments**
- ★ **All industrial instrumentation**

Space donated by: SUNVIC CONTROLS LIMITED
Crown House, Aldwych, London WC2
Manufacturers of process control and nuclear instrumentation, components & electronic instruments & data handling systems

SIMA

THE SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION

Tick **No 49** on reply card for further details

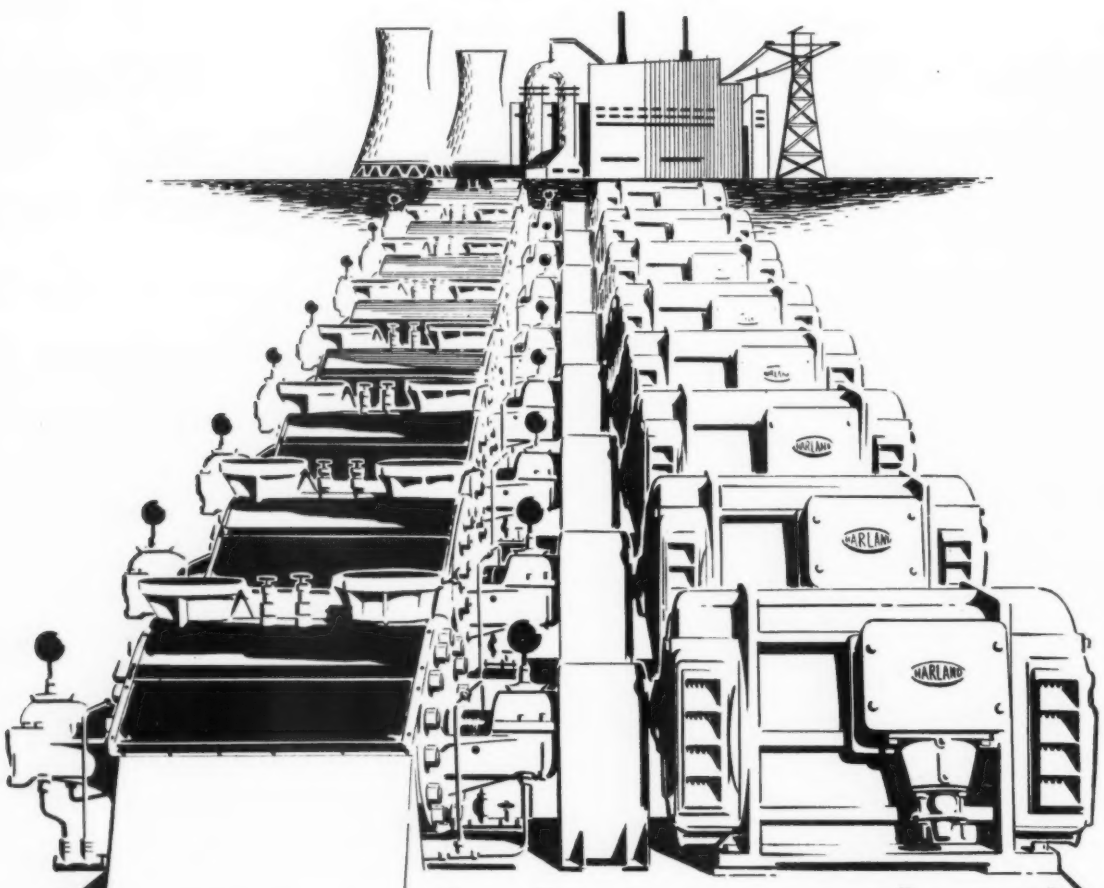
HARLAND

BOILER FEED PUMPS

at

Bradwell

On behalf of the Nuclear Power Plant Company, Messrs. C. A. Parsons have placed with Harland the contract for 10 groups of boiler feed pumps complete with motors for this major nuclear power station to be commissioned by the Central Electricity Authority within their first Nuclear Power programme.



THE HARLAND ENGINEERING CO LTD ALLOA SCOTLAND

LONDON & EXPORT SALES OFFICES: HARLAND HOUSE 20 PARK STREET W1

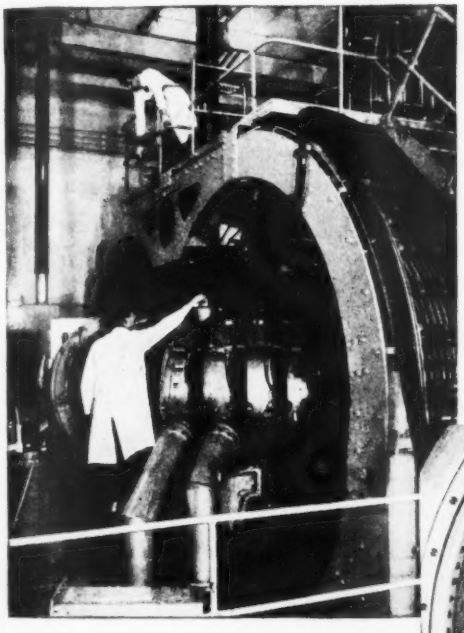
BRANCHES IN BRISTOL GLASGOW LEEDS NEWCASTLE NOTTINGHAM TIMPERLEY (Cheshire) WOLVERHAMPTON & Overseas

III

TEDDINGTON BELLOWS
and Nuclear Power
HARWELL PAYS A TRIBUTE

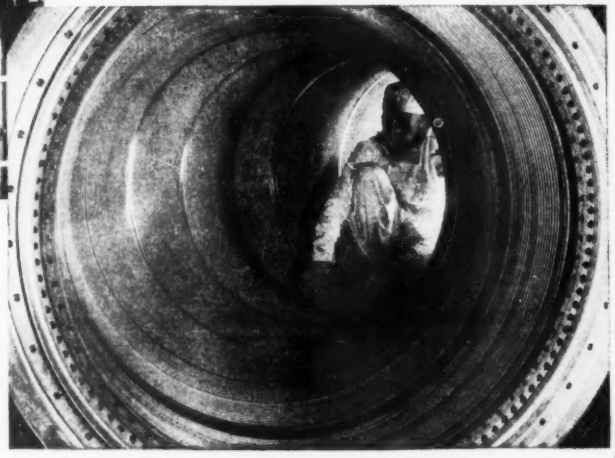
Harwell top research scientists have freely acknowledged * that recent improvements in the operational efficiency of Zeta owe much to the introduction of a corrugated stainless steel liner inside the aluminium 'torus'. Having decided to use such a liner, they turned to Teddington engineers who, out of their experience in adapting their bellows expansion joints to various demands in a wide field of industry, produced exactly what was required for satisfactory running over long periods.

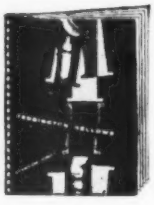
* *In a paper read before the I.E.E. on 29/30 April 1959 by Mr. J. T. D. Mitchell of the U.K.A.E.A., Harwell*



In Zeta, experiments towards controlling fusion have resulted in gas temperatures of several million degrees centigrade being achieved for millisecond periods. View showing the torus.

This stainless steel liner has improved operational characteristics and requires less maintainance than the original aluminium liner system. Here is part of the twelve welded sections of Teddington stainless steel bellows tube of wall thickness 0·017"; it has 2½ convolutions per inch of a depth of 0·75". The bellows is 38 inch bore and the whole toroidal bellows assembly has an axial length of 37 feet and an electrical resistance of 0·02 ohms.





SEND FOR HANDBOOK

Illustrated descriptions are given of the many and varied problems that Teddington Bellows Expansion Joints can overcome. If you did not secure your copy at the Engineering Exhibition, please write for one.

Teddington Bellows are produced in technical collaboration with the Solar Aircraft Co., U.S.A.

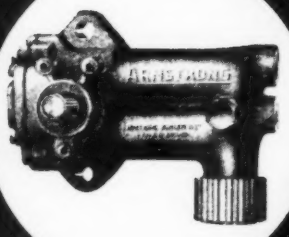
TEDDINGTON
STAINLESS STEEL BELLOWS

TEDDINGTON AIRCRAFT CONTROLS LTD. (*Industrial Bellows division*)
Ammanford, Carms. Tel.: Ammanford 2255

ZETA

Tick **No 51** on reply card for further details

A CHALLENGE TO THE WORLD!



1909
GOLDEN JUBILEE
1959

THE ARMSTRONG OFF-THE-SHELF ACTUATOR

The unparalleled convenience of a first-class hydraulic circuit, bought "off-the-shelf" at low cost and installed by the use of elementary engineering knowledge, simple instructions and a few stock embodiment items. This represents the Armstrong Actuator's challenge to the world.

Only the Armstrong Patents Company, because of its unique position in the field of hydraulics, could offer an Actuator of this quality at the price. The Armstrong Actuator is a perfect piece of hydraulic engineering (it has the right pedigree!). It does away with the need for heavy or complicated linkages, giving smooth, positive action with none of the troubles associated with links, levers or pins. Once installed and charged it will function efficiently for as long as the machine or structure in which it is embodied. The Armstrong Actuator can be used in power circuits or manually operated circuits.

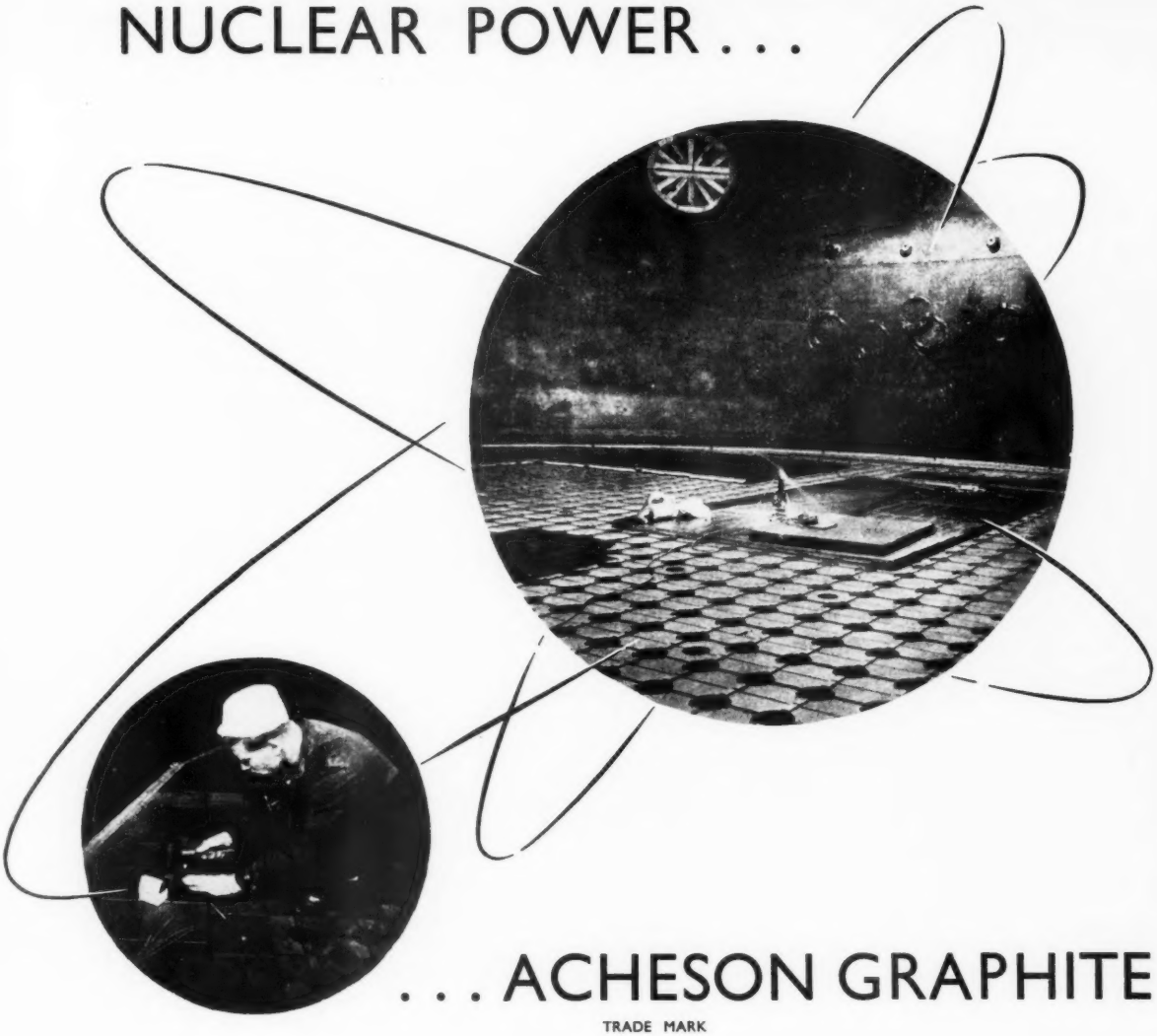
Illustrated literature containing more specific information on the Armstrong Actuator is available.

Write for Sales Leaflet APL 51/21

ARMSTRONG PATENTS CO. LTD. EASTGATE, BEVERLEY, YORKSHIRE

Telephone: BEVERLEY 82212

NUCLEAR POWER . . .



. . . ACHESON GRAPHITE

TRADE MARK

In its work as a neutron brake the pile moderator performs an exceptional role in the reduction of neutron velocities to thermal values for the continued promotion of the natural uranium fission process. In this function 'Acheson' Graphite is playing a supremely vital part. In close collaboration with the United Kingdom Atomic Energy Authority 5,000 tons of 'Acheson' Graphite conforming to an exceptionally strict specification for purity were supplied for the Calder Hall 'A' reactor.

Many thousands more tons of 'Acheson' Graphite in nuclear qualities are in train for Britain's Atomic Power Stations.

ACHESON

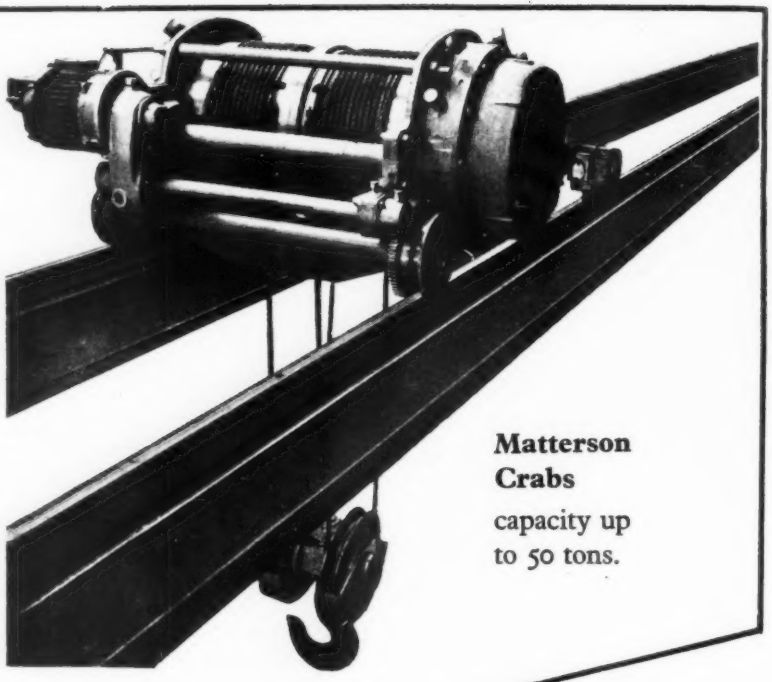
TRADE MARK

GRAPHITE ELECTRODES

The term 'ACHESON' is a registered trade mark

BRITISH ACHESON ELECTRODES LTD., WINCOBANK, SHEFFIELD PHONE: ROTHERHAM 4836

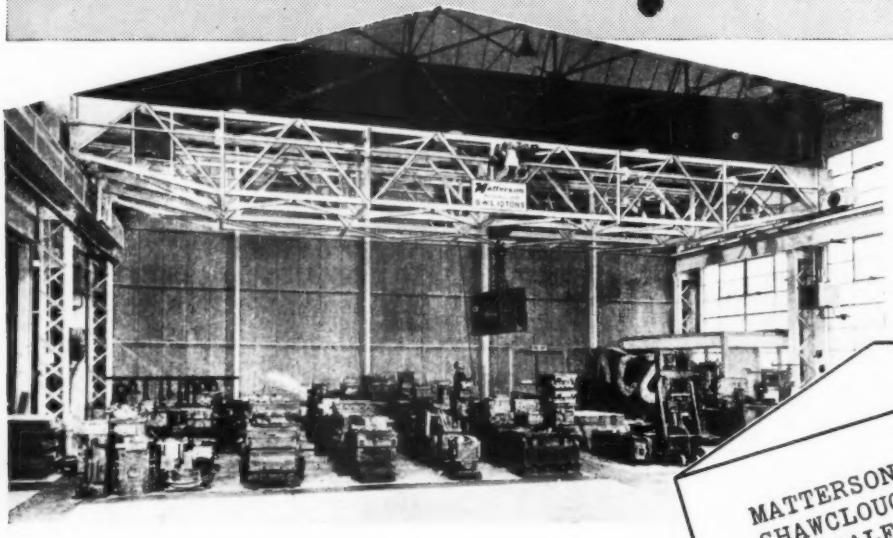
Quality and service combined with low cost and high performance, in a comprehensive range of truly British Cranes and Hoists—your inevitable choice Matterson the modern name for Cranes.



Matterson Crabs capacity up to 50 tons.

Matterson

THE MODERN NAME FOR CRANES



Comprehensive leaflets giving details and prices of the Matterson range of Cranes and Hoists, are yours for the asking.

Write NOW!

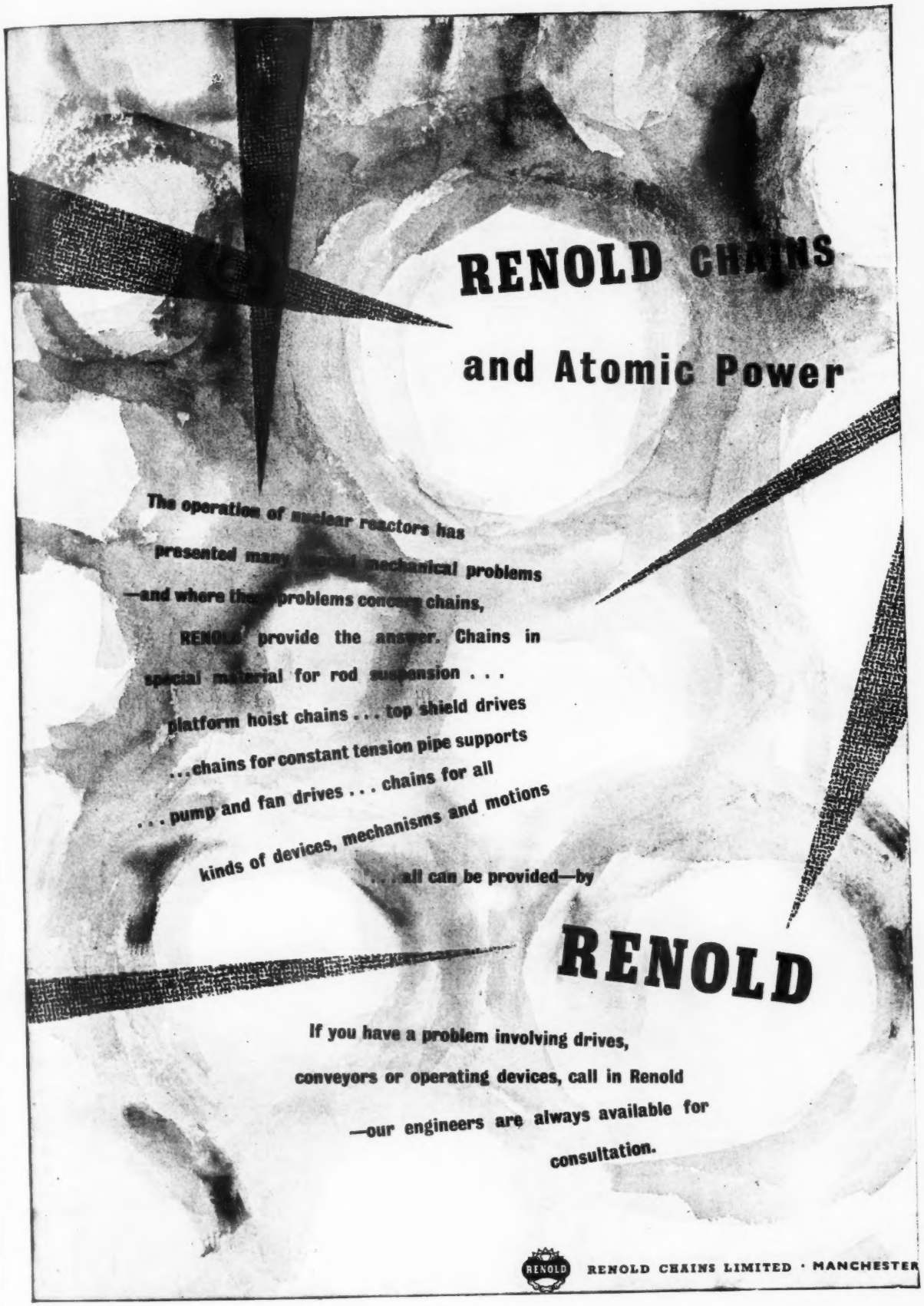
MATTERSON LIMITED,
SHAWCLOUGH,
ROCHDALE,
LANCASHIRE,

Matterson Cranes capacity up to 50 tons

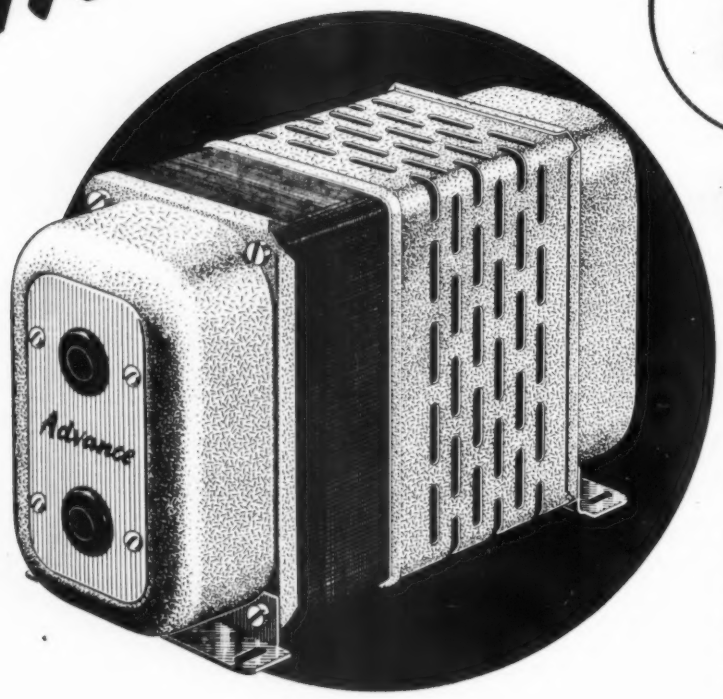
40 Years Service to British Industry

Tel.: ROCHDALE 49321

Tick **No 54** on reply card for further details


RENOLD CHAINS
and Atomic Power
The operation of nuclear reactors has
presented many
mechanical problems
—and where the
problems concern chains,
RENOLD provide the answer. Chains in
special material for rod suspension . . .
platform hoist chains . . . top shield drives
. . . chains for constant tension pipe supports
. . . pump and fan drives . . . chains for all
kinds of devices, mechanisms and motions
. . . all can be provided—by
RENOLD
If you have a problem involving drives,
conveyors or operating devices, call in Renold
—our engineers are always available for
consultation.
RENOLD
RENOLD CHAINS LIMITED · MANCHESTER

More WATTS PER £ lb



with the New

CV SERIES

Take the best in Constant Voltage Transformer design and practice . . . maintain all those features proven by years "in the field" . . . . add still greater efficiency . . . . reduce size and weight . . . . and then drastically cut the cost — and you have the NEW CV Series.

Models now available with output capacities of 25, 50, 75 and 100 watts and range of outputs from 6 to 240 volts — all providing assured output voltage regulation within ±1% for input variations of up to ±15%

- **WEIGHT REDUCED by over 25%**
- **SIZE REDUCED by over 40%**
- **STRAY FIELD REDUCED by over 75%**
- **OPERATE AT ANY LOAD from 'NO LOAD' to 'FULL LOAD'**
- **WILL OPERATE CONTINUOUSLY AT AMBIENT TEMPERATURES from −10 to +50°C.**

CONSTANT VOLTAGE TRANSFORMERS

They are **SMALLER-LIGHTER** *and* **COST LESS!**

Here's a typical example-

	MODEL CV.25/E	MODEL MT.281/E
Input Voltage	190-260V	190-260V
Output Voltage	6V	6V
Output Capacity	25W	25W
Dimensions	5½"x3 3/16"x4⅛"	7"x5½"x4⅛"
Weight	5lb	7lb
	PRICE £6.5.0	PRICE £8.0.0

Full details in Folder N.63 available on request

by **Advance** *– to be sure!*

Advance COMPONENTS LIMITED

MAINS STABILIZATION DIVISION

ROEBUCK ROAD • HAINAULT • ILFORD • ESSEX • TELEPHONE : HAINAULT 4444

GD80

So simple!

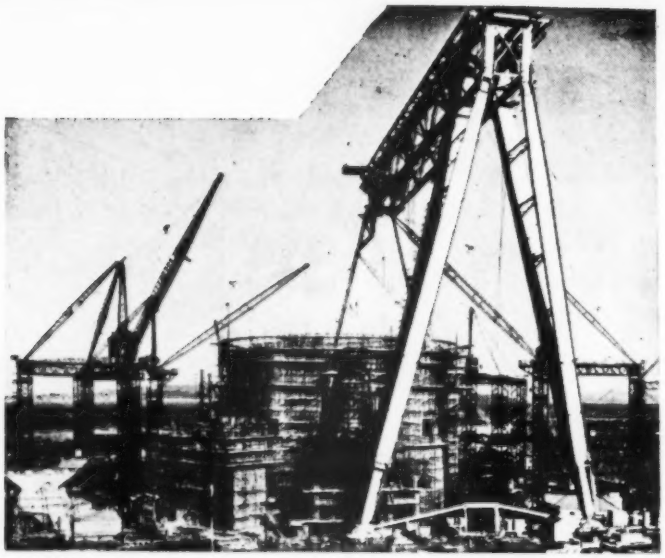
So surely SIMPLIFIX the foolproof coupling!

Simplifix couplings form a perfect joint on almost any kind of tubing including those with very thin walls. All that is required is tightening with a spanner – no special work is required on the tube and the anti-friction washer prevents the tube twisting when the nut is tightened. Simplifix couplings are suitable for all pipe line systems up to 2" o.d. In a wide range of interchangeable standard fittings. Non-standard fittings of all kinds can also be made to order. Write for further information and fully illustrated catalogue.

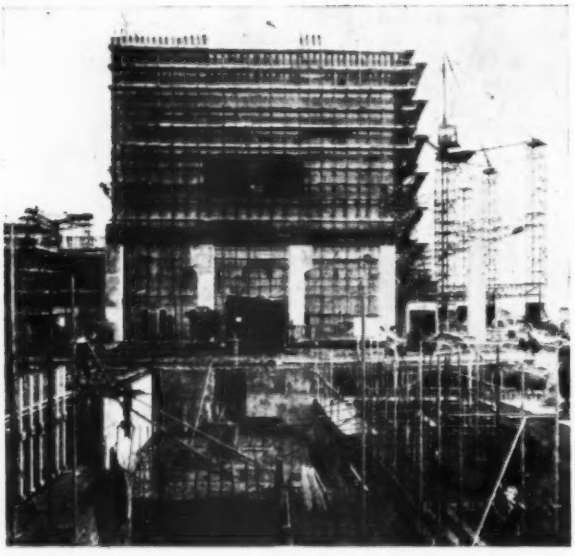
SIMPLIFIX

SIMPLIFIX COUPLINGS LIMITED
HARGRAVE ROAD · MAIDENHEAD
BERKS · TEL: MAIDENHEAD 5100
A member of the ALENCO Group of Companies

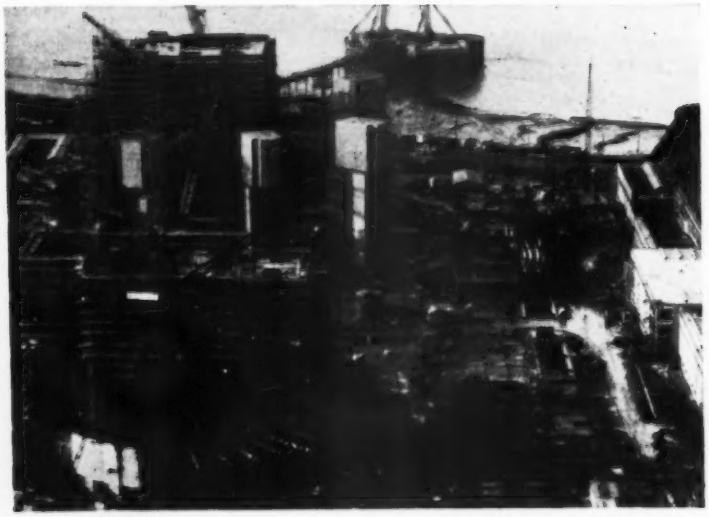
Tick **No 57** on reply card for further details



Hunterston



Hinkley Point



Berkeley

These we have served.

Reliability in Atomic Power Stations is vital. For 50 years we have supplied Electric Control Gear of the highest efficiency and reliability for use in the world's most important installations.

You too may have your own control gear problems.

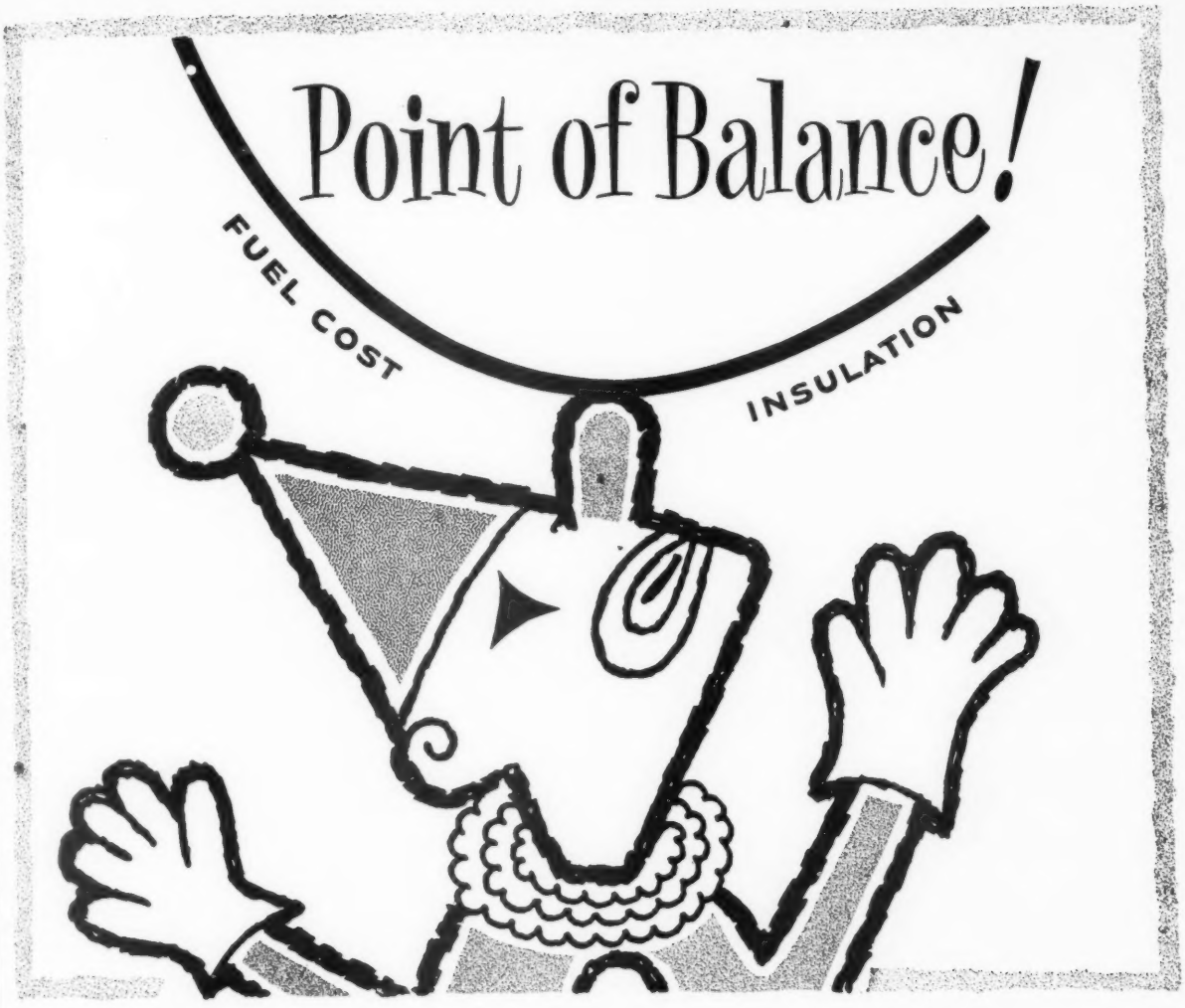
Bring them to EMB and benefit from the 'know-how' we have acquired.

E.M.B. Co. Ltd.

WEST BROMWICH——ENGLAND

Tick No 58 on reply card for further details

Point of Balance!

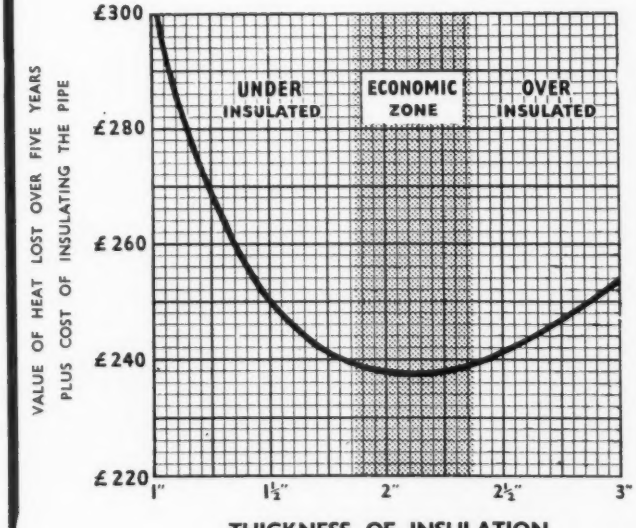


Economic Thickness of Insulation

It may be true that 'the more you insulate the more you save', but insulation costs money too! — somewhere there is a point of maximum overall economy.

This graph is based upon a typical example. It shows how costs rise for lesser thicknesses of insulation than the 'economic' owing to excessive wastage of heat. On the other hand costs also rise for greater thicknesses because the extra saving is not offsetting the cost of extra insulation. Because the insulating efficiency of Stillite insulation is particularly high it may be used *thinner* than many contemporary materials and will thus usually give an equal or greater saving at lower cost.

If you would like to pursue the potential savings possible through the use of Stillite Insulation further or to explore other technical aspects of thermal insulation, you will find the Stillite Technical Manual invaluable. As a reader of Nuclear Power we will gladly send you a copy on request.



STILLITE

Regd. Trade Mark

STILLITE PRODUCTS LTD.

15 Whitehall, London, S.W.1. *WHItehall* 0922/6.
and 231, St. Vincent St., Glasgow. *Central* 4292.

SOLID GLASS

RADIATION SHIELDING WINDOWS

Measuring up to 4 ft. 6 inches x 3 ft. x 10 inches thick or up to 12 inches thick for slightly smaller sizes. Available as polished glass blocks or as complete composite windows fully framed for insertion in the shielding wall. A range of densities is available in both stabilised and unstabilised glasses.

Our Technical Advisory and Design Service exists to help you solve your Radiation Shielding Window problems. Please write to us for full details.

CHANCE-PILKINGTON OPTICAL WORKS
Pilkington Brothers Limited
St. Asaph · Flintshire

THE WORK OF YEARS

The transfer of heat from gas to steam in large quantities and at high pressures, and all the technical, mechanical and manufacturing problems associated with that work has been our special problem since the days of the small power station boiler.

Our activities in the field of nuclear heat exchange is a natural outcome of this experience.

Flash welding an element for Hunterston.

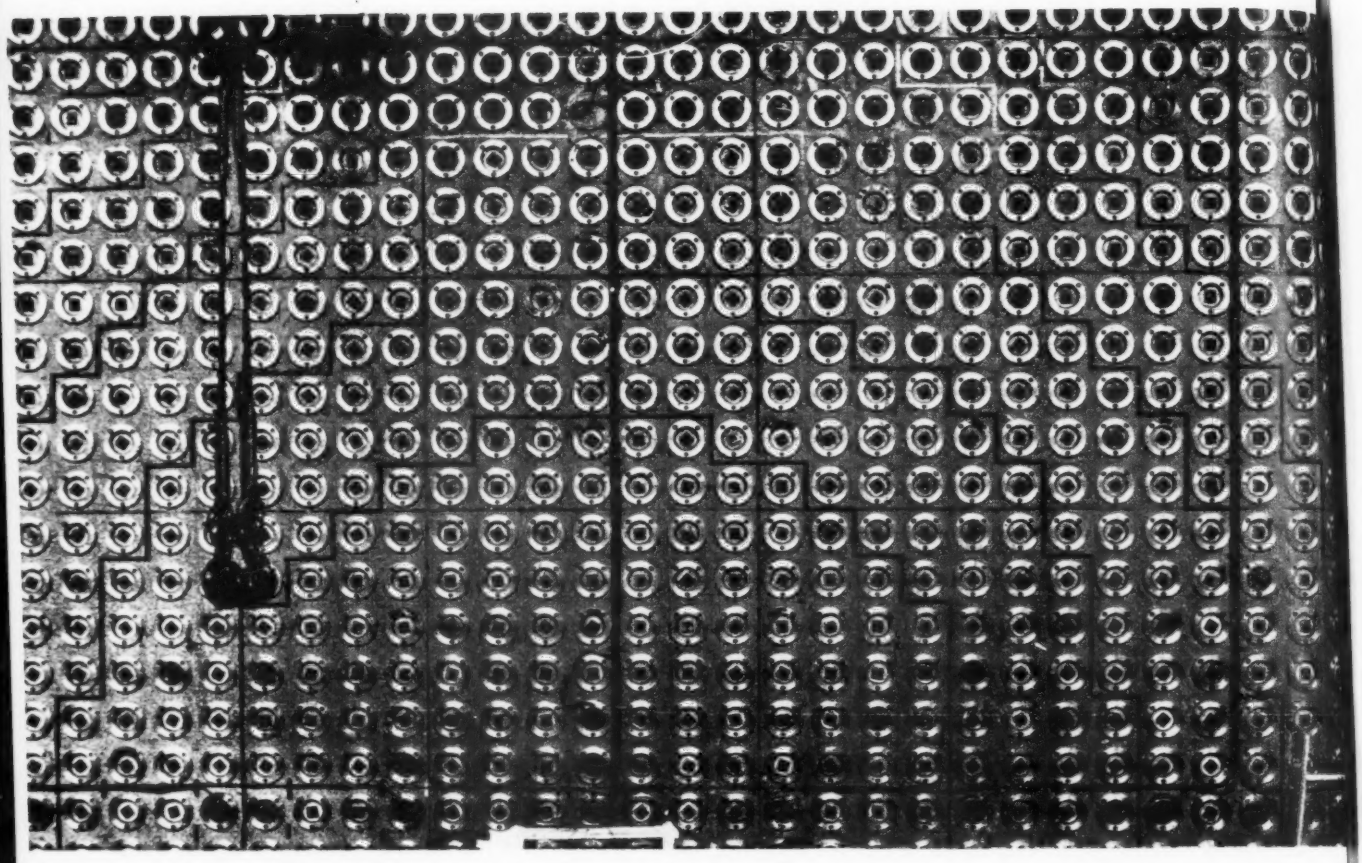
THE SUPERHEATER CO. LTD.

97, TOTTENHAM COURT ROAD, LONDON W1

THE AUTHORITY ON SUPERHEATED STEAM

Tick **No 61** on reply card for further details

A BREAKDOWN HERE COULD COST A FORTUNE



What is the most important piece of machinery in your factory ?

What would be the cost per day to your business if it were to break down ?

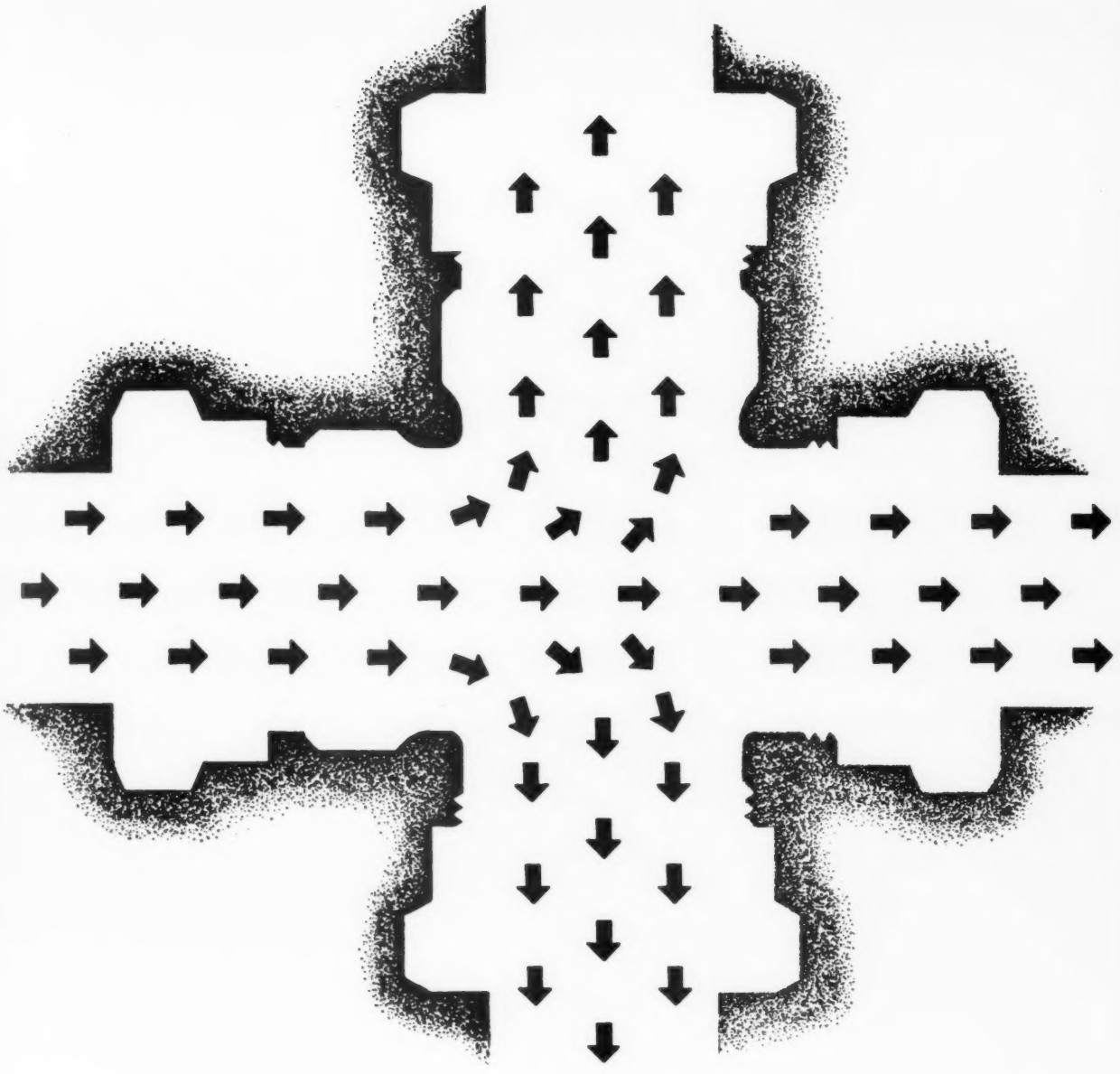
It is now possible to cover the loss of profits resulting from such a breakdown as well as the cost of repairing the machine itself.

Policies can be issued to meet the particular requirements of any business.

In this way you can be indemnified against the serious interruptions to your business which can be caused by machinery breakdown.

Should you feel in need of the protection of this new form of insurance we can send an engineer to advise you and inspect your plant.

Write to **D. H. EVERS,** *Industrial insurance consultant*
ONE ARUNDEL COURT · JUBILEE PLACE · LONDON · S.W.3



In connection with high pressure

ERMETO HIGH PRESSURE COUPLINGS are specified by many leading manufacturers, because they are the most reliable fittings on the market for every high pressure installation. Our catalogue illustrating the full range of standard fittings will be sent to you on request.

Non-standard fittings can also be made to suit your specification. Our technical experience is at your service.

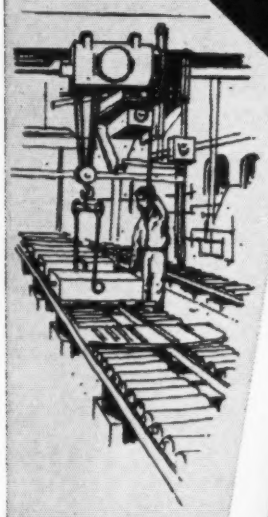
BRITISH ERMETO CORPORATION LIMITED

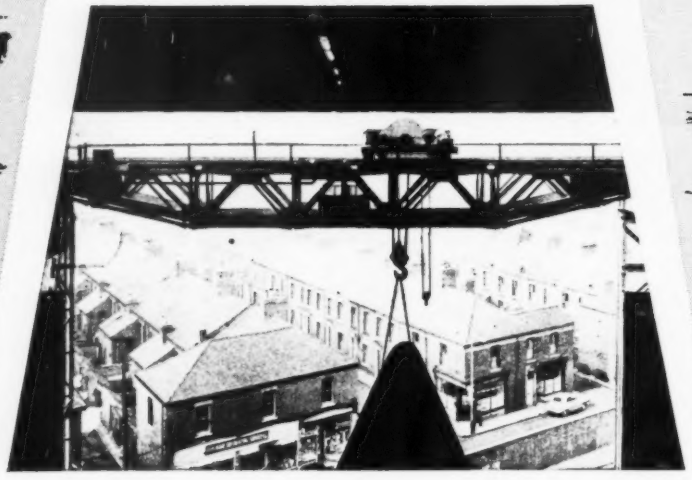
Hargrave Road • Maidenhead Berks • Telephone: Maidenhead 5100 • A member of the ALENCO Group of Companies

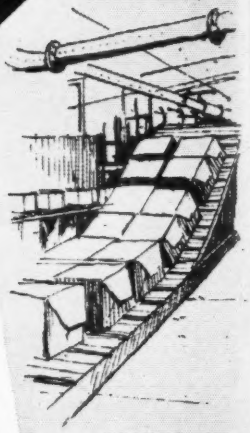
ERMETO

Tick **No 63** on reply card for further details

PATERSON HUGHES
ENGINEERING COMPANY LIMITED





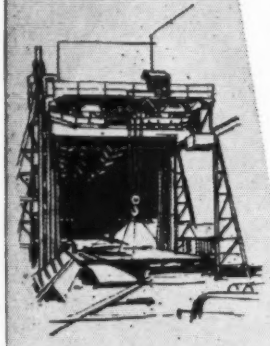


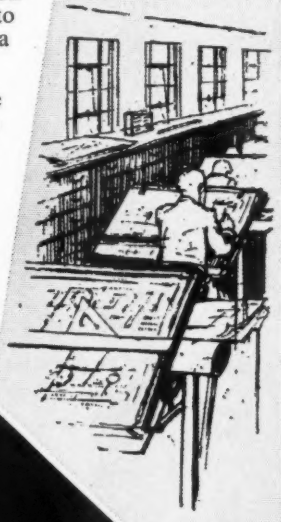
A Paterson Hughes 30-ton electric overhead travelling crane at Blyth Dry Dock and Shipbuilding Co. Ltd.— by whose courtesy this photograph is reproduced.

Paterson Hughes cranes are built in their modern crane shop in Scotland to designs based on their 35 years of experience in this field.

If the Paterson Hughes range—from hand jibs to 100-ton overhead cranes—does not include a standard model suited to your exact needs, then a special will be designed at a competitive price.

Paterson Hughes engineers will also design complete crane systems, extending from your goods inwards bay to the finished products warehouse, bearing in mind the special requirements of each industry.





THE PATERSON HUGHES

CRANE DIVISION

Specialists in modern crane practice

BIRMINGHAM
3 Highfield Road
Edgbaston Birmingham 15
Phone: Edgbaston 2957-8

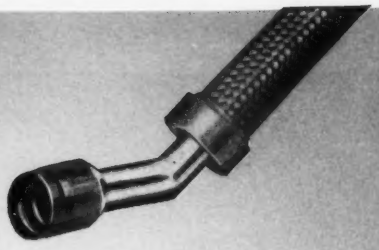
GLASGOW
Wyndford Works
Maryhill Glasgow
Phone: Maryhill 2172-4

SOUTH AFRICA—Paterson Hughes Engineering SA (PTY) Ltd PO Box 811 Johannesburg

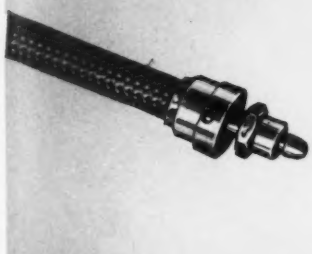
LONDON—Bedford House Bedford Street London WC2 Phone: Temple Bar 7274-6

P.2114

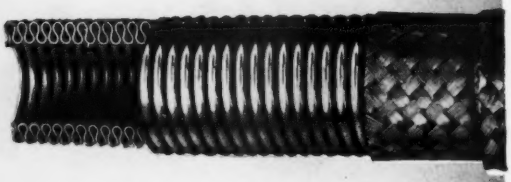
959



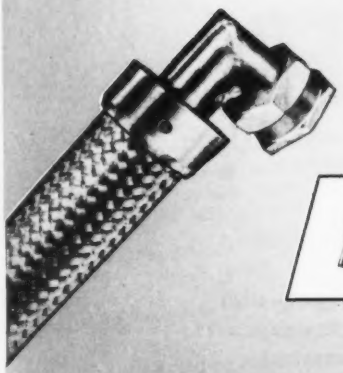
Nucleonics and Plessiflex



Plessiflex is acknowledged to be the best flexible stainless steel hose for most applications—and is particularly outstanding in the field of nucleonics. Produced from solid drawn tubing, Plessiflex is absolutely seamless and immensely strong. As a result Plessiflex may be employed simultaneously as a hoist rope and as a gas or fluid connector with the minimum of extensibility. It is ideal for charging machines, cable conduits, gas ducts, remote pneumatic handling or safety monitoring circuits. High purity aluminium, nickel or zirconium hoses can also be supplied for special applications.



If you have a problem which could be solved by the employment of flexible hose—consult Power Auxiliaries Ltd. Specialists in this field, Power Auxiliaries Ltd., have built up extensive design experience which is readily available to all equipment producers.



PLESSIFLEX

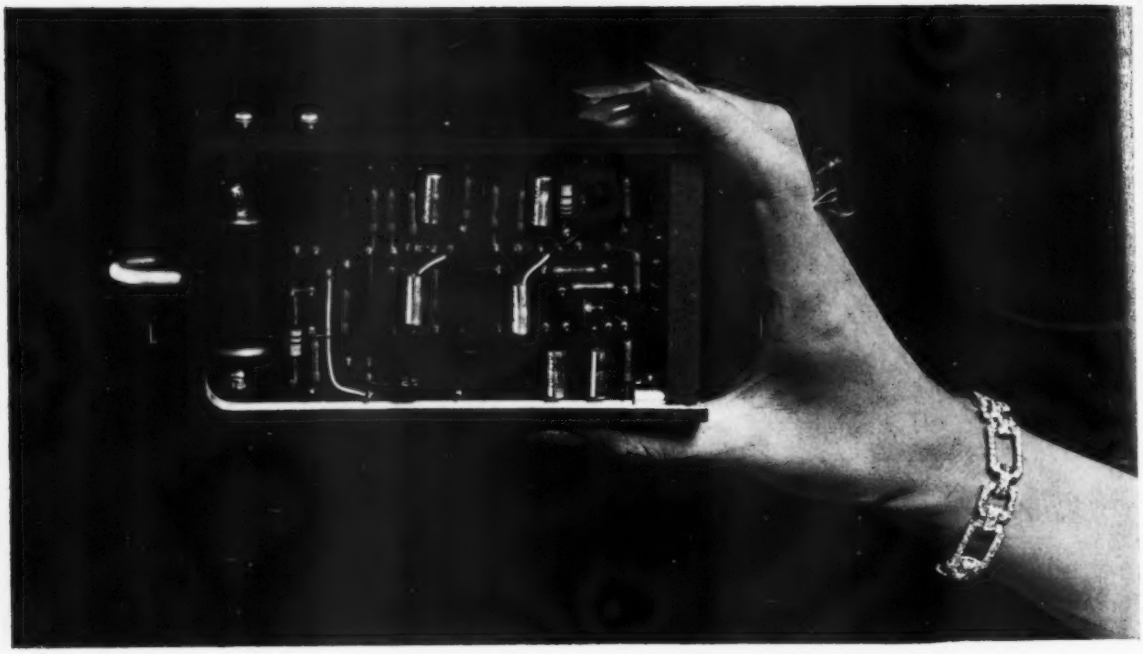
flexible seamless metallic hose

Power Auxiliaries Ltd., Kembrey Street, Swindon, Wilts. Phone: Swindon 6211

One of the Plessey Group of Companies

PAL 5

Tick No 65 on reply card for further details



NEW COMPREHENSIVE TRANSISTORISED NUCLEAR INSTRUMENTS

One of the sub-units used in a wide range of TRANSISTORISED REACTOR CONTROL, COUNTING AND SUPERVISORY INSTRUMENTS of superior performance including: —

Comprehensive Scaler ND.1571
Comprehensive Deviation Meter ND.1611
Comprehensive Shut-down Amplifier ND.1621
Comprehensive Rate and Period Meter ND.1581
Comprehensive Logarithmic D.C. Amplifier and Period Meter ND.1631
Micro-microammeter ND.1601
E.H.T. Supply ND.1591
Gamma Compensated Ion Chamber E.H.T. Supply ND.1671
D.C. Trip Amplifier ND.1231

The use of versatile **PLUG-IN SUB-UNITS** is one of the factors achieving in this range of instruments: —

- ★ Low Cost
- ★ High order of reliability
- ★ Robust, compact design
- ★ Very low heat dissipation
- ★ Simple maintenance

Elliott Nucleonics Ltd.,
Century Works, Lewisham,
London, S.E.13, England

ELLIOTT NUCLEONICS IS A MEMBER OF THE ELLIOTT AUTOMATION GROUP.

Flexible HOSES and hose FITTINGS

Lockheed Avery flexible hoses meet most requirements for pressure or vacuum and employ a range of reusable end fittings which may, if required, be assembled to the hose on site.

The following types are standard:

Type 14 Low/Medium Pressure Hose. Sizes ¼" to 2"
Cotton braided hose, lined and covered with synthetic rubber. For working pressures of 850 to 75 p.s.i., according to size.

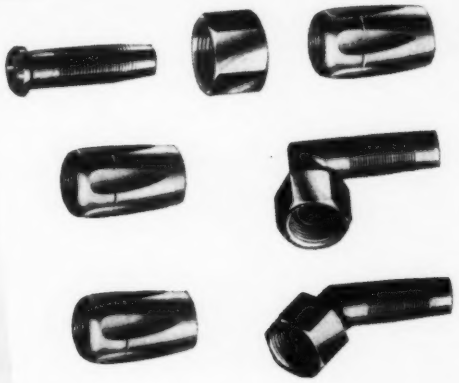
Type 14WR Low-Pressure/High Vacuum Hose. Sizes 1¼" to 5"
This type is 'tailor made' to order. For working pressures of 200 to 100 p.s.i. according to size.

Types 75, 76, 77 and 78. High-Pressure Single Wire Braided Hose. Sizes ⅛" to 2"
Choice of four different linings, to resist practically every oil, chemical, spirit or acid in ordinary industrial use. For working pressures from 4,500 to 500 p.s.i., according to size.

Type 99 High-Pressure Double Wire Braided Hose. Sizes ¼" to 2"
Lined and covered with Neoprene, high-duty construction throughout. Suitable for hydraulic fluids, diesel oil, petrol, etc. For working pressures of 5,500 to 1,000 p.s.i., according to size.

NORMAL TEMPERATURE RANGE FOR ALL HOSE –40C TO + 100C

AVERY DIVISION
LOCKHEED PRECISION PRODUCTS LIMITED
SHAW ROAD, SPEKE, LIVERPOOL, 24
Telephone: Hunts Cross 2121 *Telegrams: Lockheed, Liverpool, 24 Telex 62394*
REGD. TRADE MARK: LOCKHEED

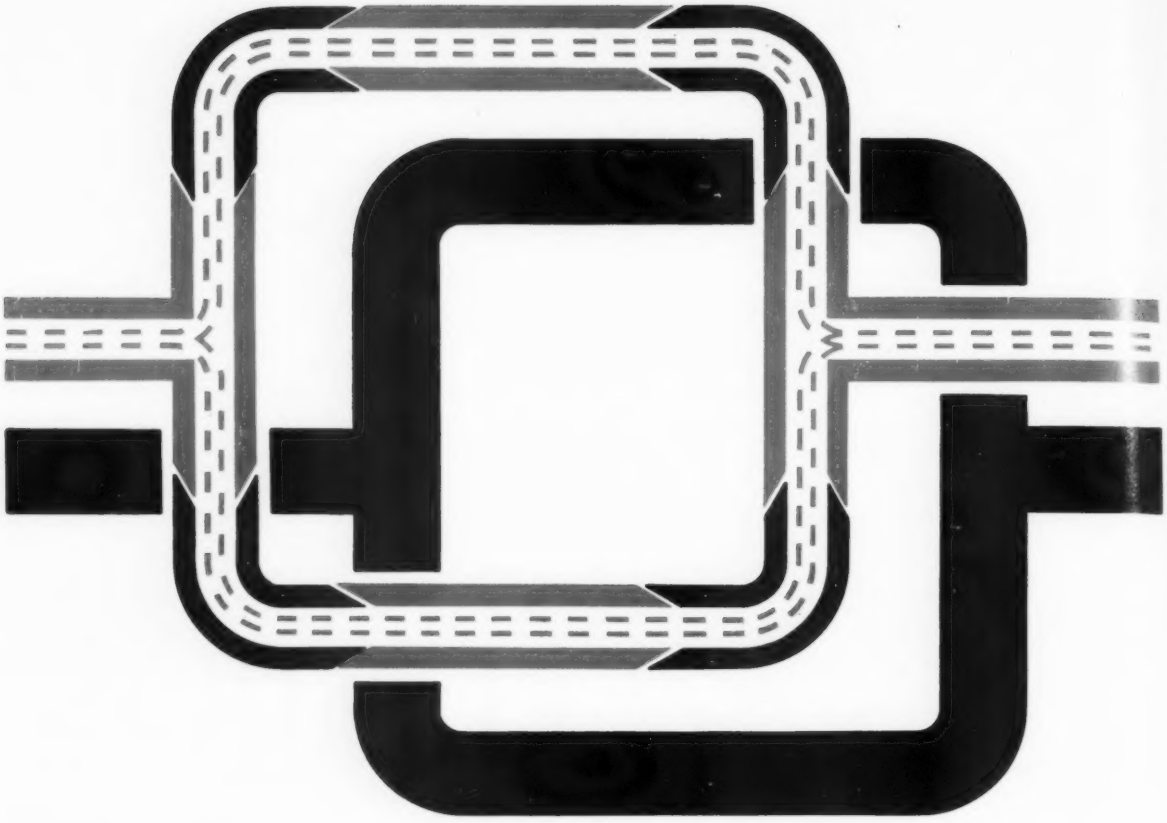


These reusable end fittings are made of steel, cadmium plated. Some types also available in gun-metal or light alloy.

Lockheed Avery self-sealing couplings can be used with these hoses and end fittings; they instantly seal off the pipes when disconnected and prevent entry of air when reconnected.

Lockheed Avery

ONE OF THE AUTOMOTIVE PRODUCTS GROUP



Your piping problems solved

A new type of piping which will carry corrosive liquids,
solvent vapours and the like, at elevated temperatures,
is now solving many maintenance problems and
thus reducing operating costs in chemical and other plants.
Made from 'Epikote' resins reinforced with glass fibre,
these pipes are as strong as drawn steel and much lighter.
They can be made to any desired shape or section:
tailored, in fact, to meet the most complex requirement.
Ask now for details of 'Epikote' resins
and their many structural uses. (Please quote No. EE.7)

EPIKOTE EPOXY RESINS

SHELL CHEMICAL COMPANY LIMITED

In association with Petrochemicals Limited and Styrene Products Limited

REGIONAL OFFICES:

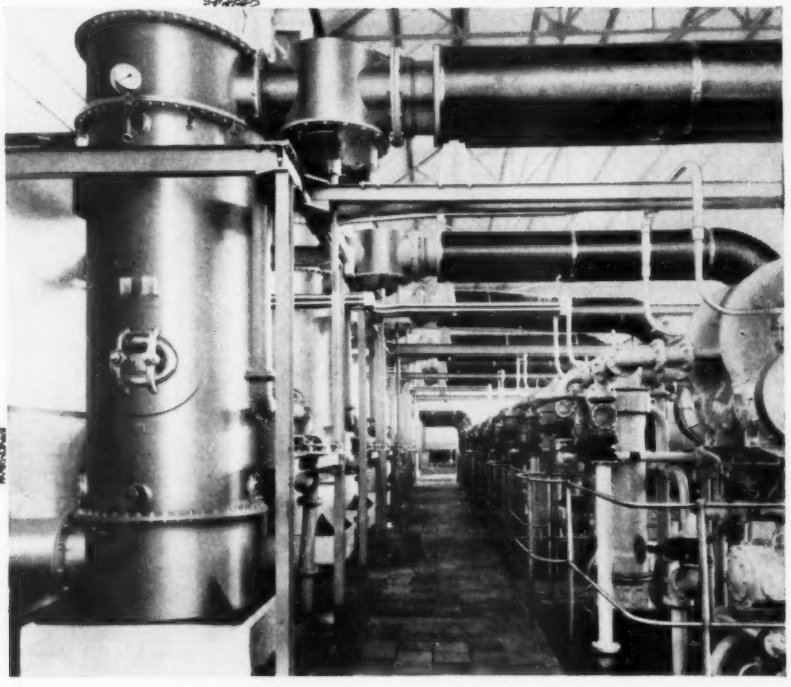
SOUTHERN	Norman House, 105-109, Strand, London, W.C.2. Tel: Temple Bar 4455
MIDLAND	Warwick Chambers, 14-20, Corporation Street. Birmingham, 2. Tel: Midland 6954
NORTHERN	144-146, Deansgate, Manchester, 3. Tel: Deansgate 2411
SCOTTISH	48-54, West Nile Street, Glasgow, C.1. Tel: City 3391
IRISH	16-20, Rosemary Street, Belfast, Northern Ireland. Tel: Belfast 26094
	33-34, Westmoreland Street Dublin. Republic of Ireland. Tel: Dublin 72114

"EPIKOTE" is a Registered Trade Mark.

SWIRLYFLO
WASTE HEAT

BOILERS AND WATER HEATERS

MARINE
*
POWER STATION
*
TRAIN HEATING
*
INDUSTRIAL



These boilers produce from 20% to 50% more steam at a higher working pressure than other makes of waste heat boilers, and are fitted with SPANNER patent Swirlyflo Tubes which are largely responsible for the outstanding success of SPANNER BOILERS. Write for leaflet.

Swirlyflo Tubes.

Enquiries to:

SPANNER BOILERS LIMITED

WOKINGHAM ROAD, BRACKNELL, BERKS
TELEPHONE: BRACKNELL 1500
TELEGRAMS: SWIRLYFLO, BRACKNELL, TELEX TELEX: 84130

Tick **No 69** on reply card for further details

Continued Success of

Plessey

BSD Equipment

- *CALDER A*
- *CALDER B*
- *MARCOULE, FRANCE*
- *CHAPELCROSS A*
- *CHAPELCROSS B*
- *BRADWELL*
- *WURENLINGEN, SWITZERLAND*
- *KARLSRUHE, W. GERMANY*
- *DIDO, HARWELL*
- *HINKLEY POINT*
- *LATINA, ITALY*
- *PLUTO, HARWELL*
- *DMTR, DOUNREAY*

AND NOW

- **Trawsfynydd, N. Wales**
- **WTR, Canada**
- **AGR, Windscale**

The accumulated knowledge, development facilities and manufacturing technique of Plessey Nucleonics Ltd. are available as a technical service to design engineers in every related field of Nuclear Instrumentation. Plessey engineers are currently giving this service to U.K. and overseas authorities.

Plessey

PLESSEY NUCLEONICS LIMITED

Weedon Road · Northampton · TEL: NORTHAMPTON 4966

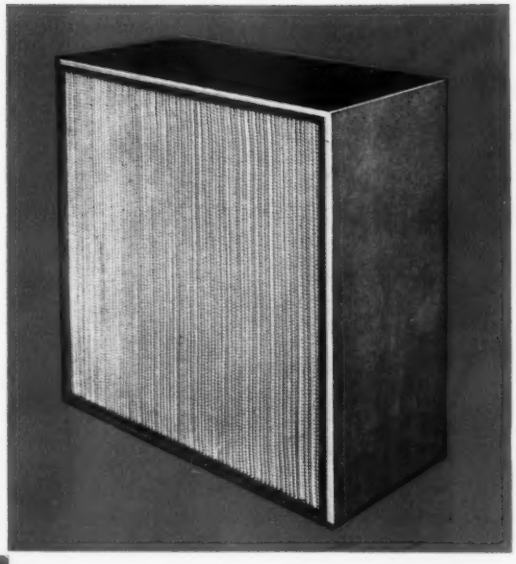
Overseas Sales Organisation: Plessey International Limited · Ilford · Essex · Tel: Ilford 3040

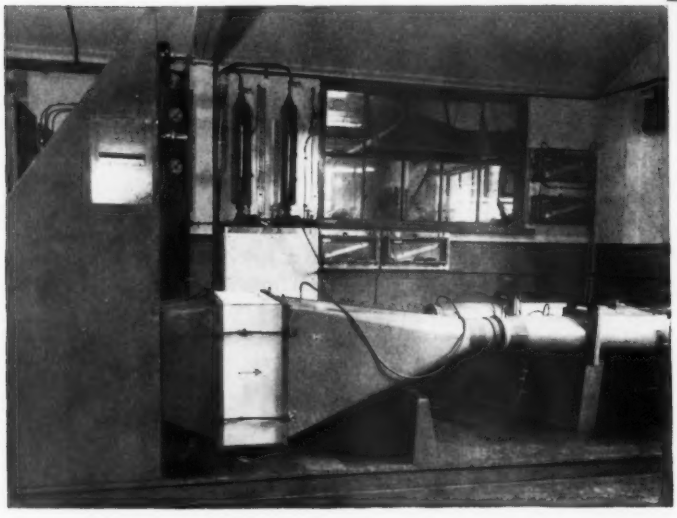
PNL15

Vokes now offer flame-proof 55 'ABSOLUTE' filter panels

which fully meet U.S. Atomic Energy Commission, Bulletin 80 28/7/58 and current requirements.

Vokes filters are playing an important part in the vast programme of nuclear development both in the United Kingdom and many overseas countries. A vital contribution was the introduction of the Vokes 55 'Absolute' filter range which deals with dangerous dust particles in the 0.1 to 0.5 micron range and has a methylene blue dust cloud test efficiency in excess of 99.95% . . . **a contribution still further increased by the addition of 'Absolute' types for applications where flame-proof construction is required.** High Temperature panels are also available for use where operating temperatures as high as 1,000°F. are prevalent.





and remember . . . . . .

Initial efficiency of 99.95% against a standard methylene blue test cloud in the 0.1 to 0.5 micron range ***is guaranteed***. Efficiency rises with use. Every Vokes 'Absolute' filter is fully and individually tested before despatch and is unreservedly guaranteed.

Our engineers will be glad to give you full details of the Vokes flame-proof and high temperature 'Absolute' filters and to discuss your particular problem with you, in order to ensure maximum safety operation.

VOKES

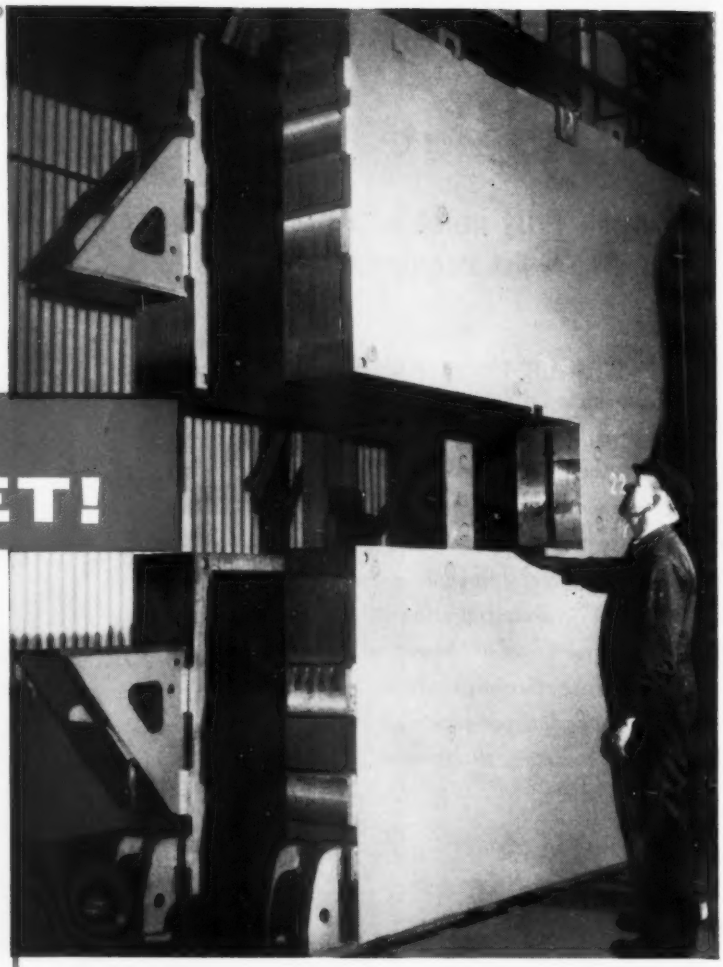
VOKES LIMITED · GUILDFORD · SURREY

Tel: Guildford 62861 (6 lines)
Grams. & Cables: Vokesacess, Guildford. Telex.
Telex: 13-535 Vokesacess, Gfd.

VOKES AUSTRALIA PTY. LIMITED, SYDNEY REPRESENTED THROUGHOUT THE WORLD

V502

FIRST IN THE FIELD—STILL IN THE LEAD



SOME MAGNET!

WHEN 52-year-old Mr. I. Danks was a boy, magnets could easily be hidden in one's pocket. Now a Foreman Erector at Joseph Sankey & Sons Ltd., Manor Works, Ettingshall, Wolverhampton, he is admiring some 20 ton magnet sectors —two of 336 that go into a 7,000 ton magnet core—the biggest in the British Commonwealth and heaviest in Europe outside the U.S.S.R.
The magnet core, accurate to one-two-hundredth of one inch and to one-half of one degree, which is for Britain's most powerful 'atom smasher'—the 7 GeV proton synchrotron at the National Institute for Research in Nuclear Science, Harwell, is weld assembled with the aid of Lincoln Electric Co. Ltd. MULTIWELD O.V. and NUWELD 1 $\frac{5}{32}$" electrodes, which are used exclusively for the welding of the side plates to the magnet sector and for the welding of the coil bracket assemblies respectively.

NUWELD 1

A NEW fast low hydrogen iron powder type electrode recently introduced from Welwyn Garden City, is also employed for the welding of the coil brackets to the magnet sector, where full penetration of a double Vee preparation with a 95° included angle is demanded.
For top welding performance to the most exacting requirements leading engineers like Joseph Sankey & Sons Ltd., rely on Lincoln Electric Co. Ltd. electrodes.
We shall be glad to show **you** the benefits that MULTIWELD O.V., NUWELD 1, and other electrodes like them can bring in **your** welding shop.
Please write today to:

LINCOLN ELECTRIC CO LTD

WELWYN GARDEN CITY · HERTS · ENGLAND
TELEPHONE: WELWYN GARDEN 920 (5 lines) 4581 (5 lines)
CABLES & GRAMS: SHIELD-ARC WELWYN GARDEN CITY

GKN

SM109

CO_2 for Industry

The Distillers Company Limited supplies carbon dioxide and all necessary storage and handling equipment to nuclear power stations, and to industry generally. The Company's bulk storage and supply system, operating in conjunction with the D.C.L. fleet of road tankers, is the most efficient and economical method for all users of the product, whether large or small.

We can advise you on all aspects of your CO_2 installation. Supplies of CO_2 are readily available from branches and depots throughout Britain.

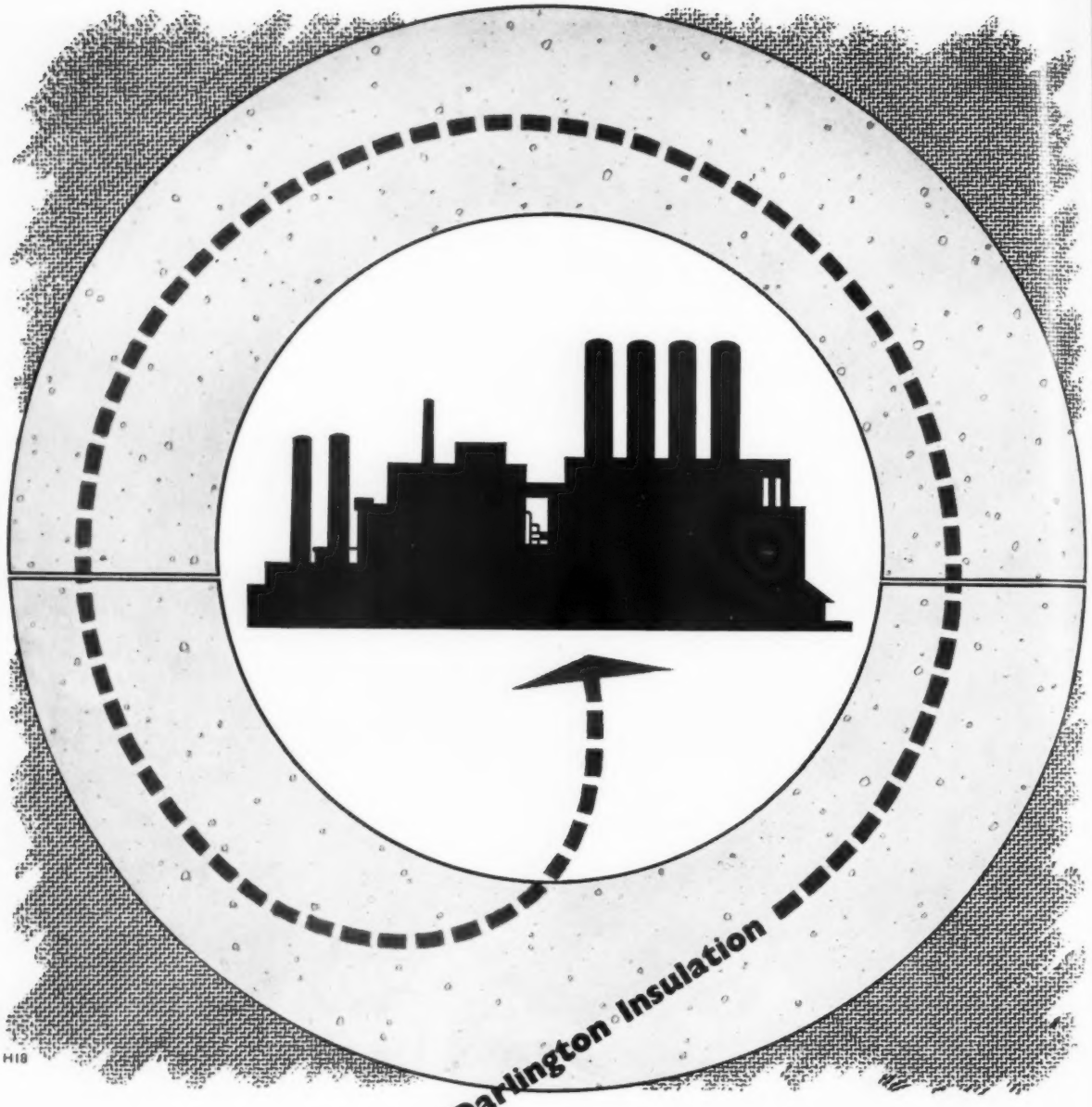
DCL

THE DISTILLERS COMPANY LIMITED, CHEMICAL DIVISION

CARBON DIOXIDE DEPARTMENT, Devonshire House, Piccadilly, London W.1 Mayfair 8867

TA/2531

Tick **No 73** on reply card for further details



High Thermal efficiency means Darlington Insulation

Year after year the Central Electricity Generating Board's list of power stations with the highest operating efficiencies includes a majority of stations where the efficiency is guarded by Darlington Insulation. In the 1957 list, for example, the top four stations are Darlington insulated.
Coincidence ? Not a bit of it ! Just skill and years of experience, plus careful specifications and the right materials.
It's The Darlington Insulation Company's job to help maintain high thermal efficiencies, and they do it very well.

THE DARLINGTON INSULATION CO. LTD

38 Great North Road, Newcastle upon Tyne, 2
and branch offices at London, Birmingham, Bolton, Bristol, Cardiff, Glasgow, Leicester and Sheffield.

A Member of The Darlington Group of Companies

Circle No 75 on reply card for further details

WESTON

MOVING COIL

RELAYS

The simplicity and reliability of relay control for a wide variety of applications has led to the ever increasing use of Weston Moving Coil Relays. Let us have a note of your relay problems and we will be pleased to advise on the most suitable model for any set of conditions. Enquiries should, if possible, be accompanied by full particulars of both control and local circuits.

Illustrated is the Model S170. Other types include the Model S124, a magnetic contact relay which operates with a minimum power input of 0.004 microwatt and the Model S115, a miniature relay, which functions as an "on-off" switching relay.

SANGAMO WESTON

SANGAMO WESTON LIMITED
ENFIELD · MIDDLESEX
Tel: ENField 3434 (6 lines) & 1242 (6 lines) Grams: Sanwest, Enfield

Scottish Factory: Port Glasgow, Renfrewshire, Port Glasgow 41151
Branches: London, CHAncery 4971 · Glasgow, Central 6208 · Manchester, Central 7904 Newcastle-upon-Tyne, Newcastle 26867 · Leeds, Leeds 30867 · Liverpool, Central 0230 Wolverhampton, Wolverhampton 21912 · Nottingham, Nottingham 42403 · Bristol, Bristol 21781 · Southampton, Southampton 23328.

SW/67

Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

PUBLISHERS COLUMN

Latecomer

NUCLEAR POWER carries this month the first full description of the station to be built at Garigliano in Italy by the US General Electric Company. The station is the first in the world to be built as a result of an international, open competitive tender, and the article, written by two senior members of GE and accompanied by plans and a cut-away drawing, represents a major scoop for the magazine and the star article in the month's issue. But quite a small drama preceded its appearance. For this issue it should have been in the office well before the end of August. However September 1st came and went and no article appeared. GE's office in New York reported that last minute problems of clearance etc. were delaying it and said that their strongest efforts were unlikely to get it here before September 10. This was really much too late and the Editor seriously considered postponing it to a later issue. But working on the principle of publishing the fastest with the mostest it was decided to risk making up a schedule in which the article would be printed later than the rest of the magazine.

The next stage was a cable informing us that the article had been put on to a plane in the evening of September 10. From then on the office was in constant touch with the GE agents in London and with the Post Office to obtain it as quickly as possible. Several helpful GPO officials worked to track down the article as soon as they could after it landed and it was duly located on the night of September 11. One of the editorial staff made a quick journey to collect it, and by midday on September 12 it was ready for the printers. The GPO officials, who had become interested in the whole thing, now expressed their intention of reading the article when it appears so it seems that the magazine may acquire some new readers in an unexpected quarter!

TOKAI-MURA

At Tokai-Mura, 70 miles north-east of Tokyo, The General Electric Company Limited of England is to build Japan's first nuclear power station. This 150 MW station will be powered by a single gas-cooled graphite-moderated reactor of the same basic type as the two which are being built by G.E.C. at Hunterston in Scotland. In producing a design to ensure the safety of the installation even under severe earthquake conditions, G.E.C. and her associate Simon-Carves Ltd., have brought to bear the results of much experimental work. For example, models of the pressure vessel mounted on a supporting skirt were subjected to horizontal loads such as would arise from earthquake shock.

Unique protective devices will be provided capable of effective operation even if the core should be severely damaged and tilted to an angle of 45°. In addition to the normal control rod system there is a unique arrangement of boron steel balls which would be released into the channels in the core by seismic pick-ups outside the station or by displacement of the pressure vessel, the core itself, the grid or various other critical parts of the reactor. The station is expected to be in full operation in 1963.

G.E.C. OF ENGLAND

ATOMIC ENERGY DIVISION

320

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND, ERITH, KENT

Tick No 77 on reply card for further details

A COMPLETE NUCLEAR ENGINEERING SERVICE AT YOUR FINGERTIPS

★ **DESIGN** Experience is vital—and our staff has been responsible for a variety of complete projects and equipment supplied to the U.K.A.E.A., at Dounreay, Windscale, Harwell, Springfields, Aldermaston, Capenhurst, etc.

★ **PROTOTYPE DEVELOPMENT** In conjunction with first class design these facilities ensure practical, reliable and proven products.

★ **MANUFACTURE** From long experience we now regard the machining and fabrication of the less common materials as our normal occupation. The welding of such steels as stainless and nickel is commonplace. Precision workmanship of the highest order stems from years of satisfying the most stringent requirements of nuclear equipment.

★ **FUNCTIONAL TESTING** It is our regular custom whenever practicable to functionally test our products before delivery. Facilities can be made available for mechanical, hydraulic and pneumatic testing. Our Vacuum Laboratory provides for prototype or production testing to exacting standards.

★ **INSTALLATION & COMMISSIONING** Many an excellent machine has been rendered unsatisfactory by faulty installation arising from a lack of appreciation of the factors involved. The accumulated and extensive site experience of our engineers is available as a technical service. Operational, Maintenance and Spares Manuals compiled on request.

RING ELMBRIDGE 7261

We shall be pleased to tender for the design and/or supply of:—

Caves · Cells · Laboratories · Remote Handling Equipment · Remotely Controlled Machines for Reactor Fuel Processing · Bellows Sealed Valves for Toxic and Corrosive Conditions · Metallurgical and Visual Examination Equipment · Glandless Pumps · Dry Boxes · Experimental Rigs for Irradiation Studies · Stainless Steel Fabrication.

PALATINE

NUCLEAR ENGINEERS

Brighton Road, Surbiton, Surrey. Tel: Elmbridge 7261-3

SIR! LETTERS TO NUCLEAR POWER

The Editor welcomes correspondence for publication

International agencies need offices

SIR: The firm or individual in the United Kingdom seeking information from the International Atomic Energy Agency or the Organization for European Economic Cooperation finds it difficult because it appears that these organizations have no offices or general agents here. There are, of course, sales agencies for their publications but enquiries or contacts have to be made either unofficially to other related bodies or by letter to Vienna or Paris.

May I suggest that it would be most helpful if these bodies would consider setting up offices or appoint official representatives in this country. If they exist already may I ask that their identity be declaimed.

Atomic Energy Department J. C. BRADBURY-WILLIAMS
Babcock & Wilcox

Scientists and civil servants

SIR: I cannot understand 'Hyperon's agitation in his letter (reproduced) about the appointment of Sir Roger Makins as chairman of the UKAEA, because his experience lies in the Civil Service rather than industry. Surely no one imagines that he is going to have to design reactors or even concern himself at all with the details of the research and development programme? His job will be to decide broad aspects of policy and it is just these aspects which need overhauling and will moreover involve some tricky negotiations with government and industry. Surely a diplomat is just what is needed in such a post? Hyperon attacks, by implication the whole present system of running the country. In this, as he must know, specialists and technicians have responsibility for carrying out policies decided by non-specialist, non-technical heads. These heads often have no experience at all in the field they are called on to lead, but they do (or should) have energy, drive and a good brain. Perhaps this is not the best system, but it has worked well enough. It is regrettable but true that specialists often lack the broad outlook which is absolutely necessary in the man at the top. It would be interesting to know something of Hyperon's own background. In his suggestions for reorganizing the atomic energy industry he shows a wide view and a sweeping disregard for essentials which it would be most surprising to find in a specialist.

London, SW1 L. O. NOWELL

Too much accounting?

SIR: Mr. G. S. Vincent has performed a useful job in codifying in a concise way the economic arithmetic of gas-cooled reactors ('The Economics of Gas Cooled Reactors,' NP, September 1959, p 88–92). In particular, his method of taking into account the interest on capital during construction is interesting and is the first attempt I have seen to allow for this not inconsiderable factor.

In the present state of the art, however, the situation is still clouded by uncertainties which presumably will not be resolved until the first round stations have been operating for some time. Assuming, how-

LIGHT ALLOYS in nuclear research and development

Birmetals

Light alloys in all wrought forms

The large scale production of the special magnesium alloy used to make the fuel element cans for Calder Hall was the result of collaborative experimental work by Birmetals Limited and the United Kingdom Atomic Energy Authority.

Similar collaboration between Birmetals, the U.K.A.E.A. and the commercial constructors of nuclear power plants is ensuring continued development in this and other allied metallurgical fields.

BIRMETALS LIMITED · WOODGATE WORKS · BIRMINGHAM 32

BM 221

Tick No 79 on reply card for further details

We specialise in the supply of

NUCLEAR METALS AND COMPOUNDS

Boron & Borides

Boron Carbide
(Nuclear Grade)

Calcium

Cerium

Europium

Fabricated Fuel Elements

Gadolinium

Hafnium

Lithium

Niobium

Samarium

Tantalum

Thallium

Thorium

Uranium

Vanadium

Yttrium

Zirconium

Zircaloy

Please Submit your Enquiries and Problems to

NEW METALS & CHEMICALS

LIMITED

Chancery House, Chancery Lane, London, W.C.2

Telephones: HOLborn 7415 (8 lines)
Teleprinter: London 28816

SIR!

continued from p 77

ever, that Vincent's values for his various parameters such as capital cost, burnup, plutonium credit, etc., are in fact realized, the competitive picture of nuclear power versus coal power is a lot darker than was supposed even a year ago.

But the nation as a whole must be wary of taking a cost-accountant's view of nuclear power. It is completely wrong to consider uranium and coal as two contenders in an economic 15-round contest. Both are absolutely essential to our future economy and one of the first jobs if our new Government should be the hammering out of an integrated national fuel policy. In this, they must never forget that while uranium is just a fuel, coal is much more than that. After all, wheat can be made to burn quite satisfactorily but we don't go around shovelling it into furnaces.

Edinburgh P. J. ANDREW

Is Merlin illegal ?

SIR: I am a little puzzled about the legal status of A.E.I.'s Merlin research reactor. In your August and September issues you publish pictures showing it in operation. Yet in September you have an article on the new Act which requires reactors to be licensed. Has Merlin got a licence or is it running illegally ?

Wolverhampton P. CHASE

▶ *As you will see from September p. 94 the Act is not yet law. When it comes into force it is true that Merlin, unless a licence is simultaneously issued for it, will technically be in an illegal position.* *Ed.*

Strange standards

SIR: I was interested to see from your last issue (*Publisher's Column—Editor*) that for mathematical abbreviations you intend to follow British Standard 1991 'with two minor exceptions.' I was wondering whether you would be prepared to divulge these or whether it is up to the reader to try and detect them.

Manchester 17 S. H. ROBERTS

▶ *No, it's no secret. Our deviations from the BSI are as follows: 1. The BSI would have us print* $\frac{dy}{dx}$ *and although there are mathematical arguments for this, it hinders the printer a great deal. We therefore prefer* $\frac{dy}{dx}$. *2. The BSI urge us to write 11 492. This, we consider, looks like a misprint and we decided to keep to 11,492.* *Ed.*

Those slugs

SIR: If attempts to force the term 'fission product detection' into common usage have failed, as suggested by *Gracchus* in August, it is a great pity. This term is by far the most sensible and descriptive so far suggested. After all it is the fission products that are detected, not the slugs, cans or what have you. Agreed it is the failed elements that one is really interested in but we don't just want to detect them: we have to locate them. Thus we should really have something like 'failed element location equipment' But I think 'fission product detection'—which is already in limited use—is far preferable.

Hyde, Cheshire R. H. HANCOCK

The latest slant on fuel sheathing
Fuel cans in a variety of forms are one outlet for nuclear metals produced by I.C.I. Metals Division — aluminium and magnesium alloys, zirconium, niobium, vanadium and beryllium.
first in nuclear metals
IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1
ICI
METALS DIVISION
NC38

Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · FABRICATION
OCTOBER 1959 VOLUME 4 NUMBER 42

UK lags on high temperature reactors

ENTHUSIASTS for the high temperature gas-cooled reactor in this country will receive with very mixed feelings the news that US General Dynamics and the Philadelphia Electric Co. have got their contracts from the Atomic Energy Commission for construction and operation of a 40 MW plant. They will be pleased that the Americans have come round to their view of the importance of the system—$40 million is to be spent on it and no less than 51 electricity supply companies have joined forces to support it. They will be less pleased to recall the AEC chairman's statement last February that when this reactor is completed the US can expect to be ' several years ahead of other countries in this very important nuclear development '.

It is pretty well recognized now that there is no chance of catching up with the Americans in the field of water reactors. Are they to be allowed to jump into the lead on gas-cooled reactors as well—to develop the culmination of the system which has come to be associated especially with the United Kingdom? And not only the Americans have been converted: the Krupp/Brown Boveri group in Germany are now to build a high temperature reactor. Of the three countries interested, Britain, the originator of the concept, is now the only one without a programme to build a plant of its own. Indeed, it is an open secret that if the UK had not managed to get OEEC backing for the joint *Dragon* programme the AEA might well not have considered it worth while to build a reactor itself.

Opinion within the Authority has always been sharply divided on the HTR. When the system was first conceived it attracted little interest. One of the men principally responsible for it left for America and is now working for General Dynamics. Later it gained increasing support in the Research Group, but to this day the two industrial Groups regard it as a rather remote possibility. This country's effort may be limited to the hundred or so men to be attached to the *Dragon* project and construction for this is unlikely to start within a year.

This is more than a pity. The American and German programmes at the moment may be unrealistic; for General Dynamics to keep to their schedule and complete building in 1963 with graphite canned fuel elements would be little short of amazing; even their alternative of getting the reactor satisfactorily in operation by the October 1 deadline with metal canning would be an immense achievement. The German pebble-bed reactor plan jumps over so many intermediate stages that it will be rather surprising if it works at all. But at least these countries are getting down to building something. The UK, which at the present time has a clear lead in this technology, especially in the vitally important graphite techniques, is very likely to lose it unless it steps up its own effort considerably.

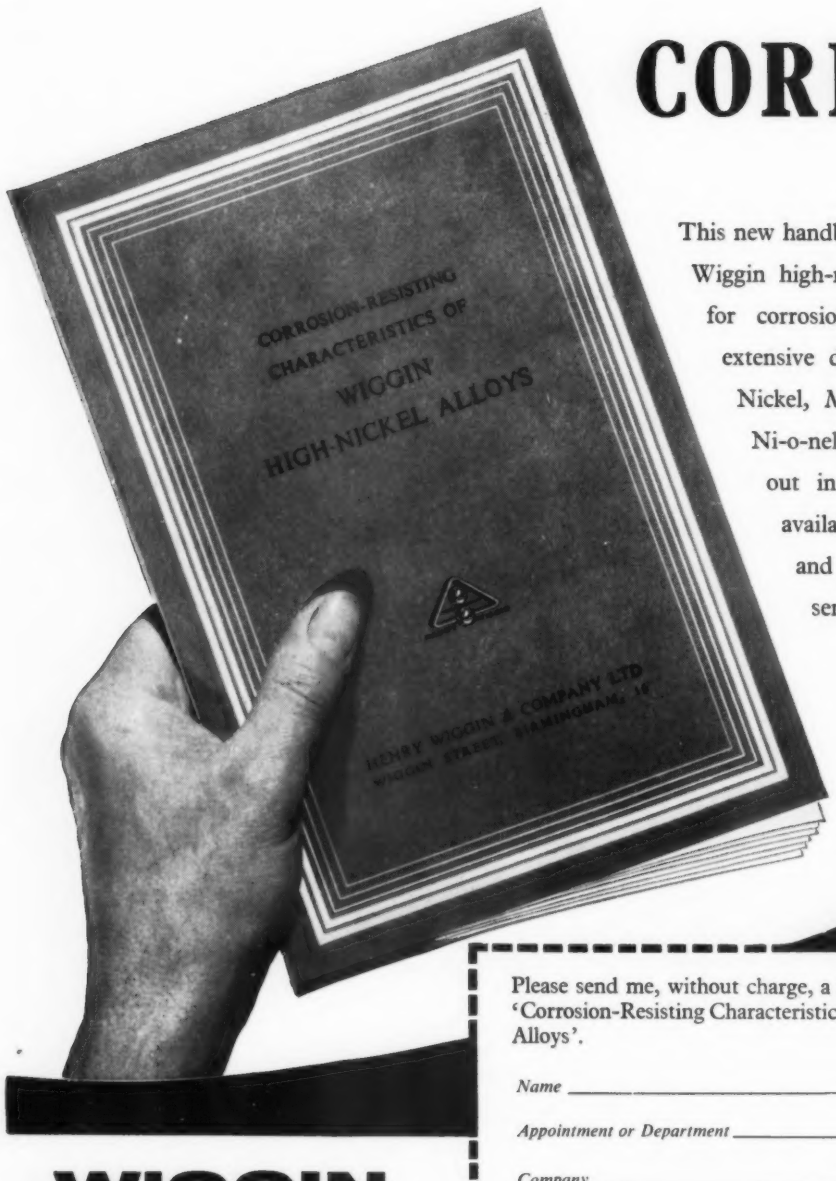
Exodus

SHORTLY after the Atomic Energy Authority disclosed to the Select Committee on Estimates that it would be pleased if it could get as many as three more men from industry for senior posts comes the news that Harwell is to lose its chief engineer. Mr. Dolphin's departure is depressing in itself—he is a very able engineer and has done some extremely valuable work for the Authority—but it is also a symptom that the exodus of staff is reaching alarming proportions. At the same time, despite strenuous efforts, the Authority has been unable to attract senior men from outside: in 1958, out of the 46 people serving in the top posts of the former Industrial Group, for example, only three had come straight into those jobs from outside the Authority. Lower down the scale it is the same story. Men at the vital £2000 a year level just will not join in sufficient numbers.

The Authority's policy for dealing with the situation is simply to make the best of a bad job. To fill the senior posts junior men are being promoted as fast as possible (and in some cases too fast); in five to seven years' time, at a superficial glance, there will be plenty of senior men. The problem of shortage in the middle ranges will be eased by restricting the development projects undertaken. All in all it is a pretty barren prospect, and the Authority is well aware of it. Unfortunately, if it is possible to be seriously worried and complacent at the same time, then the Authority leaders are performing the feat. The situation is entirely caused, they maintain, by the old enemy: they are instructed by the Government not to pay salaries seriously out of scale with those paid by other public corporations. These salaries sometimes compare unfavourably—especially at the top levels—with those which can be secured in the lush pastures of industry. But is this really the complete answer? Many of the men working for the Authority have another, subsidiary perhaps, but still important. They would say that the Authority grows more like the civil service every day; that irritations caused by bureaucratic methods are increasing, that scope for initiative is decreasing—that the whole organisation in fact is slowly fossilizing. If this is true, and the indications are that it may be, then the Authority *can* do something about its staff problem. To keep a sense of initiative and flexibility alive in an organization of this size is extremely difficult, but it is a problem that must be tackled more energetically.

Knowing where to find the answers on

CORROSION



This new handbook describes in detail the many Wiggin high-nickel alloys specially developed for corrosion-resisting duties. It includes extensive data on the properties of 'AT' Nickel, Monel, Inconel, Corronel B and Ni-o-nel, and gives results of tests carried out in many corrosive media. It is available, without charge, to designers and chemical engineers. May we send you a copy?

Please send me, without charge, a copy of your publication 'Corrosion-Resisting Characteristics of Wiggin High-Nickel Alloys'.

Name _____

Appointment or Department _____

Company _____

Publications will be sent to private address, if preferred.

NP.

WIGGIN
***KNOW* NICKEL ALLOYS**

'MONEL', 'INCONEL', 'CORRONEL' AND 'NI-O-NEL' ARE REGISTERED TRADE MARKS

HENRY WIGGIN AND COMPANY LIMITED, WIGGIN STREET, BIRMINGHAM 16

TGA C3

Worldview

the month in atomic energy

Best for the Atlantic ?

London—While discussions are taking place as to the best way of supporting British prestige in the North Atlantic by way of government subsidies to build replacement for the Queens, increasing opinion has veered towards nuclear powered submarines. There is no doubt as to the prestige if the UK can successfully operate large mercantile underwater craft and under present-day conditions of warfare, such vessels would be of particular value in transporting valuable cargoes safely. In this respect Admiral Sir William Davis, Commander-in-Chief, Home Fleet, recently said ' I do not think that we have, among the strategic maritime thinkers, got to grips with the enormous possibilities of nuclear power ' and that while ordinary submarines were rather inefficient sorts of whale which had to come up to snort, nuclear powered vessels were highly efficient. Already extensive survey work has been carried out both in this country and Canada for the transport of oil and iron ore and it is only the lack of government support which is preventing such a project being initiated.

IAEA plan for next year

Vienna—The third regular session of the General Conference of the IAEA was opened here on September 22. The first part of the discussions was taken up by the programme and budget for 1960 and it is estimated that expenditure for the coming year will be some $M8¼, an increase of over $M1½ on the current year. Nearly $M6 will be drawn from the assessed contributions of member states and the balance, for Operational Funds I and II will depend on voluntary contributions—these two funds are mainly concerned with the Agency's laboratory at Seibersdorf, training programmes and technical assistance programmes.

Expanding assistance

Vienna—The IAEA is to send nuclear experts to Denmark, Tunisia, Turkey and the United Arab Republic. As, in general, experience in non-ferrous metallurgy is limited in Denmark, an expert will work with the metallurgy group of the reactor division at the Risø research establishment on the fabrication of nuclear fuel elements and sintered uranium oxide.

In Tunisia, two isotope specialists will assist in the application of isotopes for agricultural and medical purposes. For this the IAEA are providing some equipment, including counters, handling and shielding equipment, at a total value of $8285.

Backed by a grant of $8600, an IAEA expert is going to Turkey to set up a pioneer laboratory for agricultural research and give lectures and organize conferences on the use of radioisotopes to improve the quality and yield of crops.

Lacking sufficient number of qualified personnel to continue its programme, the Atomic Energy Establishment of the United Arab Republic have requested the Agency to provide the services of an expert in health physics and protection by dosimetry.

In addition to these specific missions, preliminary assistance groups of the IAEA are to make one week visits to Iran, Turkey and Yugoslavia before the end of 1959.

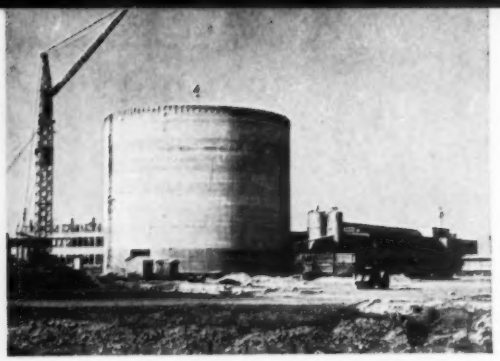
AGR GOES UP. Construction of the AGR at Windscale is proceeding well. With the experience gained from this CO_2 cooled, graphite moderated reactor, AEA expect to bring forward a power generating system costing less than £100/kW and with a major increase in fuel element life

Greater use of heavy water

Vienna—At the beginning of September an international panel was set up by the IAEA to review, assess and correlate data on the physics of heavy water lattices. As the availability and economic aspects has created a widespread interest in the use of natural uranium as a reactor fuel, particular attention has recently been given to the design of heavy water moderated reactors. The outcome of this panel's discussions will, it is anticipated, constitute the Agency's first major contribution to reactor science.

Argentinian potential

Buenos Aires—An agreement has been signed by Talleres Argentinos de Motores Diesel E.N. (TAMDEN), one of the DINIE group of state industries, and the German consortium Maschinenfabrik Augsburg Nürnberg, to form a mixed company, the Industrias MANSAIC, with a capital of 300M pesos subscribed by both partners equally. While the initial activities will include the manufacture of electric generating sets, diesel engines, machinery and repair work, this new company will prove a suitable operating base for any nuclear power stations built



AUSTRIA MOVES AHEAD. The swimming pool type of research reactor being built by AMF and the associated laboratories for the Austrian Association for Nuclear Research at Seibersdorf are nearing completion. Criticality is scheduled to be achieved by March 1960

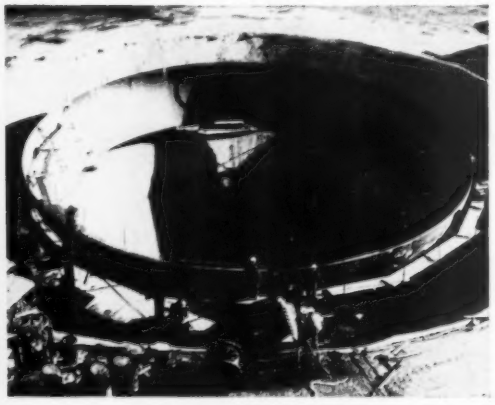
in South America under the recent GEC-MAN nuclear agreement.

Candu site fixed

Toronto—The chairman of the Ontario Hydro-electric Power Commission announced early in September that the site for the Candu nuclear power station will be near Kincardine on the shore of Lake Huron. This plant (see *Worldview*, August 1959) is Canada's first large power producing unit and when completed will have an output of 200 MW.

New centre named

Paris—An additional large nuclear research centre is to be built by the Commissariat à l'Energie Atomique at



SUPERHEATED POWER. Erection is proceeding on the containment vessel of the 20 MWe BWR at Elk River, Minn. This facility will employ a superheater in the secondary steam circuit

Cadarache in the Department of Bouches-du-Rhône. With Fontenay-aux-Roses, Saclay, Grenoble and Marcoule, this will bring the number of French research centres for nuclear energy to five. The Cadarache installation, costing some 20,000M francs, will be used to improve existing forms of reactors with special reference to the graphite moderated types. Three reactors will be used at this establishment, Pegasus, Brenda and Rhapsody. Fuel elements suitable

Worldview

for gas-cooled power reactors, such as will be used in the proposed Electricité de France stations, will be tested in the Pegasus; feasibility trials of employing gas turbines will be carried out in the Brenda reactor aimed at using enriched uranium fuel in high temperature reactors; and Rhapsody, a fast-neutron type, will be used to investigate liquid metal cooling, with the emphasis on sodium coolants. (See *Worldview*, April 1959.)

India's first

New Delhi—The Indian Parliament have indicated that they intend to go ahead with the construction of a nuclear power station. A 250 MWe capacity unit is envisaged and it is planned, at an estimated cost of Rs430M, to be located on the coast between Ahmedabad and Bombay so that it can feed into the grid covering the Bombay region.

Cutting out duplication

Rome—The Italian Government has announced the setting up of a joint committee for the coordination of nuclear activities and the preliminary meeting of it was recently held. The committee is composed of members of ENI, AGIP Nucleare, Finelettrica, SENN and SME and is the first step towards the establishment of a National Power Agency. Its aims are to avoid duplication of effort, 'out-of-place' competition and, above all, provide the Government with a unified and consistent policy.

Americans in Italy

Bari—'The impact of atomic energy in the economic development of the South' was the theme of the four main lectures held during the XXIII Levant Fair. In addition, there was an extensive nuclear exhibition which included models of Westinghouse's 134 MWe Yankee project, master-slave manipulators and electronic equipment from the United States.

New York—The Babcock & Wilcox Co has received a contract from CAMEN, the Italian Government owned research and training agency for the supply of the core and associated equipment for the Naval Academy and University of Pisa's reactor. This facility, Italy's third research installation, is of the pool type and designed to operate at 5MW capacity. It is scheduled to be ready for operation early in 1961.

Saluggia—The fourth shipment of 20% enriched uranium, in the form of uranium-aluminium alloy, aluminium-clad, has been received here for the RS.1 reactor. This AMF swimming-pool type facility will start operating in the immediate future with an initial power level of 1MW and it will be subsequently stepped up to 5MW.

Solving marine problems

Rijeka — Representing over twenty nations, some 200 legal experts attended the 24th conference of the International Marine Committee held here at the end of September. This is an advisory committee which only makes recommendations to governments on marine legal problems and this session a new code for nuclear-powered mercantile vessels, including possible hazards associated with them on the high seas was drafted.

More activity in Far East

Moscow—Following negotiations between the North Korean Republic and the USSR, an agreement on the peaceful uses of atomic energy has been signed here. Under its terms Soviet technical assistance will be given for the building of research reactor, nuclear physics and isotope laboratories and auxiliary equipment will include a betatron and cobalt sources. In addition Korean personnel will be trained in Russia and general technical assistance given to them.

Lenin goes down river

Leningrad—The world's first nuclear powered icebreaker, *Lenin* (see *Worldview*, March 1959) was cleared from the Russian naval shipyards on September 12. Three days later, the vessel sailed down the River Neva on her maiden voyage for sea trials in the Baltic. This ship of 16,000 tons displacement, whose main engines develop 44,000 h.p., is expected to attain a speed of 18 knots in icefree water. An interesting fact in a vessel of this size is that no instruments with luminescent dials are allowed on board so that accurate radiation levels may be observed and recorded. When she enters service, the vessel will be used in the Arctic on cruises of a year or more's duration.

More power for the Urals

Moscow—Construction of the Beloyarsk nuclear power station has now advanced far enough for it to be scheduled to start feeding into the grid in 1961. Two reactors will have a net output of 100 MWe each and have been designed to enable the station to operate at an efficiency of 33·8 per cent, which is higher than that of Soviet fuel-burning plants of the conventional type. Slightly enriched uranium will fuel the graphite-moderated, boiling water-cooled reactors and the secondary steam cycle will be superheated.

First in Central America

Mayaguez—The first of the two reactors at Puerto Rico's nuclear centre here went critical on August 12, having taken only three and a half months to ship and install, following fabrication by Atomics International. This 10W facility

forms part of a $M3½ AEC programme for the centre to meet all the central and southern American countries and a larger, 1MW, pool-type reactor will be completed next year. Subsequently, the larger unit will be modified to operate up to a 5MW power level.

Finance from industry

Carltonville, Transvaal — The Union Government has approved a five-year programme for the South African Atomic Energy Board which includes the building of a small research reactor. Costing some £800,000 per annum, the Government will provide £300,000 and the balance will be borne by the uranium-producing and other interested industries. The overall project will include research into uranium processing and the application of isotopes for medicines, agriculture and industry.

SRE failure

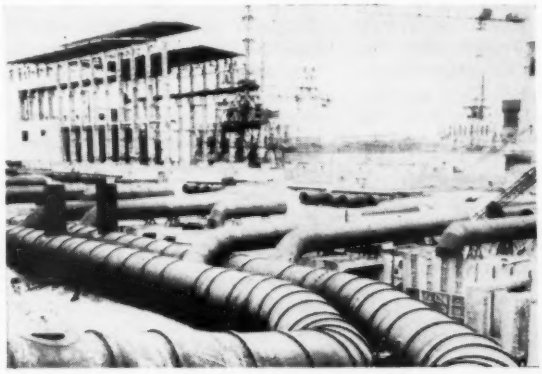
Santa Susana, Cal—During an inspection of the Sodium Reactor Experiment, SRE, here a parted fuel element has been detected. While the precise cause has not yet been ascertained, no release of radioactive materials occurred nor unsafe reactor conditions arose. This facility was the AEC's first experiment to develop a sodium-cooled, graphite-moderated and has been in operation since April, 1957. The failed fuel element was part of the loading nearing the end of its useful life and was scheduled to be removed in the near future. The second core loading is planned to be made up of thorium-uranium alloy fuel elements.

America now backs HTGR

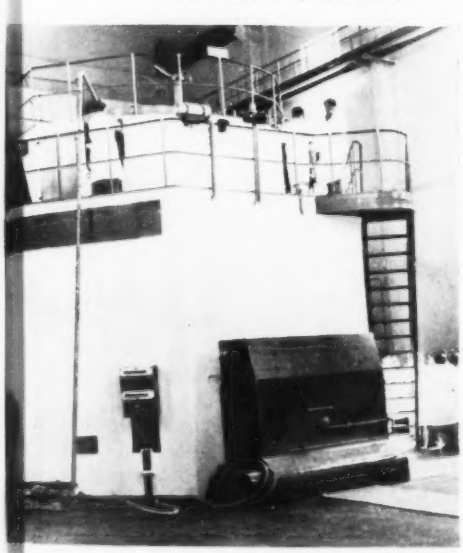
Washington, DC — Approved by the United States Congress, the AEC have signed contracts to cover the building of a 40MWe high temperature, gas-cooled nuclear power plant by the Philadelphia Electric Company and the General Atomics Division of General Dynamics. The installation, scheduled for completion in 1963, is designed to produce steam at 1450 lb/sq. in. and 1000°F., which will be high enough to take advantage of modern steam turbine conditions.

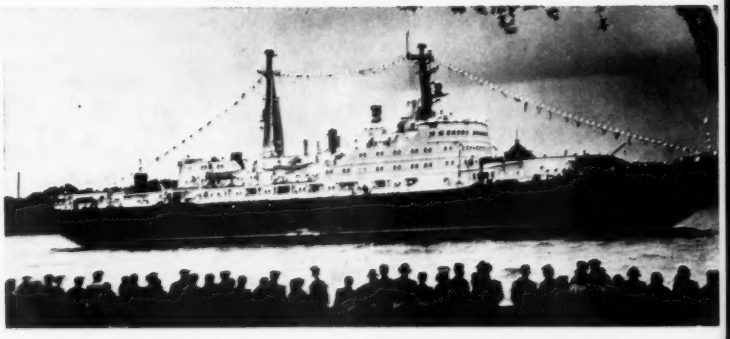
With the financial support of fifty-one other utility companies, forming the High Temperature Reactor Development Association Inc., the Philadelphia Electric Co. will construct this nuclear power station about 9 miles above the Conowingo dam and integrate it into their York County, Pa, utility system. The main engineering and construction will be under the control of the Bechtel Corp., for whom the General Atomic Division will design and provide the reactor and nuclear steam system. In addition, General Dynamics will supply the fuel elements for the plant's first five years of operation. The conventional generating plant will be supplied by Westinghouse Electric.

In support of this project the United States AEC will reimburse $M14½ for the cost of research and development and will waive both the initial fuel use charges of $M½ and $M2 charges for five years' operations. Initially metal-clad fuel elements may be used, but the

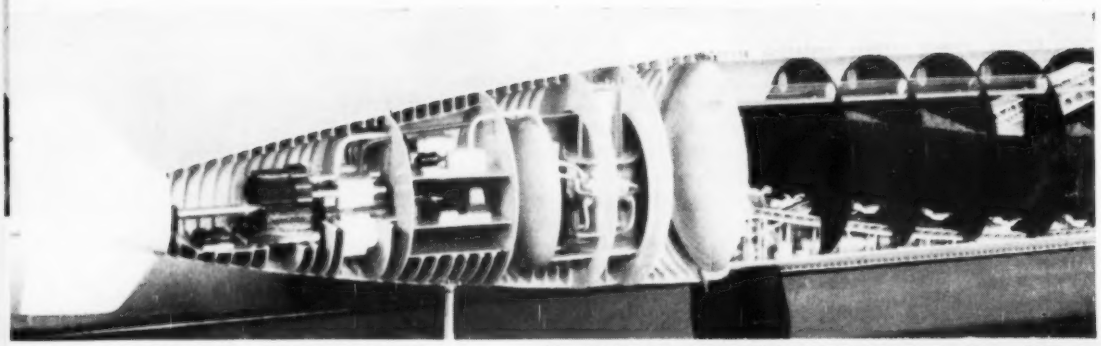


SOVIET PROGRESS. Under construction—the 210 MW Novovoronezhskaya nuclear power station (see Worldview, last month). Below, now in operation —the 2 MW research reactor of the Uzbek Academy at Tashkent





The world's first nuclear powered surface vessel, the icebreaker 'Lenin' sailed on her maiden voyage on September 15. Left, visitors on the bridge before she left Leningrad



MOBY DICK WANTS SPONSOR. Complete designs and operating studies have been made by Mitchell Engineering Ltd. for three sizes or mercantile nuclear powered submarines, of 30,000, 50,000 and 100,000 tons displacement. The 50,000 tonner, employing a 150 MW BWR is considered the most suitable as a prototype and would operate at 25 knots at 300 ft below the surface. Such a vessel would be 604 ft long, have a maximum beam of 72 ft, carry a cargo of 28,000 tons and a crew of 50

plant will eventually operate with elements of uranium and thorium dispersed in graphite and graphite-clad. In its final form, the graphite-clad core should produce more economical power costs. The value of this installation is reflected in that the fifty-two participating generating companies serve thirty-two states and some third of the population of the United States.

Heating up the steam

Canoga Park, Cal—A joint study is to be undertaken by the Nuclear Power Group and Atomics International into the feasibility of an advanced type of nuclear power reactor. The concept is aimed at producing steam at high temperatures and pressures and is based on a reactor consisting of a large pile of graphite blocks which are holed to allow the insertion of fuel elements and other holes to contain tubes carrying boiling water and superheated steam.

Idaho Falls, Idaho—The United States AEC has selected Combustion Engineering's proposal for a test reactor and contract negotiations are now in hand. The project, designated the Nuclear Test Plant, NTP, will be capable of testing reactor cores with power capacities up to 60 MWt and will include a pressurized water reactor designed to allow full-scale testing of prototype cores for military field plants developed under the joint programme of the Commission and the US Army Corps of Engineers.

New Divisions at Argonne

Lemont, Ill—Two new major scientific divisions—High Energy Physics and Solid State Science—have been formed at the Argonne National Laboratory here. The high energy physics division will aim to discover and investigate the elementary particles from which all matter is made. In the early 1960's, this division will have the Zero Gradient Proton Synchroton, ZGS, in service as its principal research tool.

The solid state science division's work will be to develop materials for nuclear use 'which will withstand conditions of temperature, pressure and radiation exposure which now seem prohibitive' says the AEC.

The International School of Nuclear Science and Engineering is to expand its activities and broaden its programme. In February 1960, when the change becomes effective, it will be known as the International Institute of Nuclear Science and Engineering and will give greater emphasis to advanced training with less background instruction. The aim will be to cover those sections of nuclear science and technology which are not normally available in universities.

More participation by industry

San Diego, Calif—The Cornell University's new Centre for Nuclear Technology is to have a General Dynamics Triga reactor. It will be of the above ground type with a steady state power level of 10 kW. Other facilities at this establishment will include a Curtiss-Wright zero power research core and a gamma radiation cell. Construction is scheduled to start at the beginning of March 1960, with completion by June 1961.

Canoga Park, Calif.—The design for a 50 MW uranyl sulphate fuelled research reactor for the Walter Reed Army Medical Centre in Washington, by Atomics International (see *Worldview*, July) has been accepted and a construction contract has been issued by the US Army Corps of Engineers. Building is starting immediately and is scheduled to be completed late next year.

Houston, Texas — A non-propelled nuclear servicing vessel is to be built for maintenance, refuelling and waste handling operations of vessels, such as NS *Savannah*.

Vienna—A 99 years lease for a 14 acres site at Seibersdorf, 19 miles east of here, on which the IAEA is to build its functional laboratory, has been granted to the Agency by the Oesterreichische Studiengesellschaft für Atomenergie GmbH. (SGAE).

New York—To provide facilities to support the US Navy's increasing nuclear development programme, a new high-level radiation laboratory is to be built by the Vitro Engineering Co. and will cost some $M1·7. It will be principally used to study radiation effects on construction materials.

Uzbek reactor critical

Tashkent—The light water moderated and cooled research reactor (see *Worldview*, June) went critical on September 10. This facility, the first in the Soviet East, is the first section of Uzbek Academy of Sciences Nuclear Physics Institute and will be available to scientists from all the Central Asian republics and Kazakhstan.

At the end of September a nuclear energy conference, attended by nearly one thousand scientists, was initiated at Tashkent and during the session it is expected that some 350 papers covering Soviet nuclear technology will be presented.

Described here for the first time, this American design by General Electric won the only open international competition for a nuclear power station to be held so far

The SENN nuclear power station

—Europe's first full-scale BWR

by V. A. ELLIOTT, *Manager, Design Engineering*
and G. J. STATHAKIS, *Manager, Overseas Power Reactor Applications*

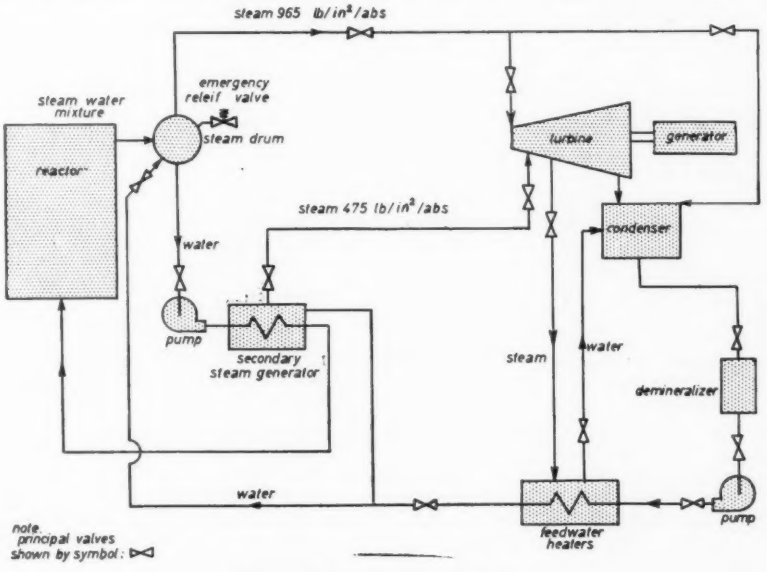
THE DUAL-CYCLE boiling water reactor system designed by General Electric was selected in September 1958 to power a 150 MW nuclear power station for the Società Elettronucleare Nationale of Italy. The plant will be located on the Garigliano River near Naples. The choice of General Electric was made by SENN in conjunction with an international team of experts sponsored by the World Bank and the Italian Government from among nine proposals from four countries. The basis of the boiling water reactor selection was: (1) a more extensive background of technical progress, (2) higher operating flexibility, (3) lower power costs, and (4) good potential for improvement in plant performance.

The simplicity of the boiling water reactor makes it attractive for an operating nuclear power plant. In the dual-cycle system, however, heat exchangers of relatively small size are used to improve operating characteristics and reactor core power density and a minimum of auxiliary systems is required. Components are similar to those in conventional power plants. Cycle efficiency is comparatively high since steam generated in the reactor is fed into the turbine at substantially reactor pressure. Because of a two-phase coolant system (water and steam), auxiliary pumping power is low.

Extensive development work has been done on boiling water reactors over the last few years. Six have been built, five are under construction, and there are commitments for four additional plants. The safety characteristics of the boiling water reactor have been satisfactorily demonstrated in the US Atomic Energy Commission's Borax and Spert experiments. EBWR and VBWR have shown stable operation at successively higher power outputs, with good operating availability and lower than expected radioactivity levels. Considerable experience has been gained in the research, development, and design of the Dresden plant (the 180 MW BWR under construction by GE at Morris, Illinois), which exemplifies the extension of the boiling water concept to a large electric utility generating station.

The BWR for the Garigliano plant is fuelled with zircaloy-clad, uranium oxide pellets. Extensive irradiation tests of UO_2 pellets indicate that they are quite stable and that the irradiation required for good fuel life will not be damaging. The oxide is also highly corrosion-resistant. It has been demonstrated in trials that zircaloy cladding is also highly resistant to corrosion at the conditions of temperature and water purity encountered in the BWR. Practical manufacturing processes for the manufacture of UO_2, zircaloy-clad fuel elements and assemblies have been developed, and many tons of fuel have been fabricated by General Electric to date.

The use of zircaloy-clad, uranium oxide fuel in a light-water-cooled and moderated BWR leads to relatively low



Simplified flow diagram (Fig. 1)

values of uranium enrichment. Power reactor fuel elements tested in the VBWR experimental power plant at the Vallecitos Atomic Laboratory of General Electric have reached burnups of about 4000 MWD/short ton, and it is expected that the company's BWR fuel elements will attain several times this burnup. The conversion of a considerable amount of U-238 to plutonium during operating assists in obtaining long fuel burnup with low enrichment.

STATION DESIGN

Cycle and performance

The reactor system selected for the Garigliano power plant design is the forced circulation, dual-cycle, light-water-cooled and moderated type. The simplified flow diagram, Figure 1, indicates the simplicity of major circuits of the main power system. In this type of reactor, energy is removed from the core directly by steam which flows to the primary turbine control valves and indirectly by extracting heat through secondary steam generators from the reactor circulating water to produce steam at a lower pressure.

The low pressure steam generated flows to the turbine through the secondary turbine control valves. The combined primary and secondary steam passes through a conventional turbine cycle with condenser, feed pumps, and four extraction feed-water heaters, and is then returned to the primary steam drum and the two secondary steam generators.

Automatic load control

The dual cycle was used because, for a given core flow rate, the permissible power density is higher than for the single cycle, and by properly controlling the two turbine flow paths, automatic load following can be attained over a considerable range without movement of control rods. Other papers on the dual-cycle reactor give more details on the control system (*1*), (*2*). Load control is carried out by means of a speed governor and an initial pressure regulator mounted on the turbine. The pressure in the reactor is held constant by regulation of the primary turbine control valves and the turbine speed governor controls secondary steam flow to the turbine. The fraction of the total energy removed through the secondary or low pressure system varies the temperature of the water returning to the reactor, which in turn controls the reactor output. Control rods are used during startup, normal shutdown, and scramming.

Calculated plant performance

A brief summary of the calculated over-all plant performance at rated load is given below:

Gross generator output	160 MW
Net station electrical output	150 MW
Reactor power output	507 MW
Net plant heat rate	11,553 B.t.u./k Wh
Reactor pressure	1,015 lb/sq in.
Secondary steam pressure	500 lb/sq in.
Turbine back pressure	1·25 in. Hg
Feedwater temperature	375°F

Plant arrangement

The plot plan of the power station is shown in Figure 2. The over-all plant consists of a 160 ft. diameter steel containment vessel, which houses the reactor, a turbine-generator and control building, a radioactive waste disposal facility, condenser intake structures, and other conventional plant such as the administration building, shop and warehouse, and the switchyard.

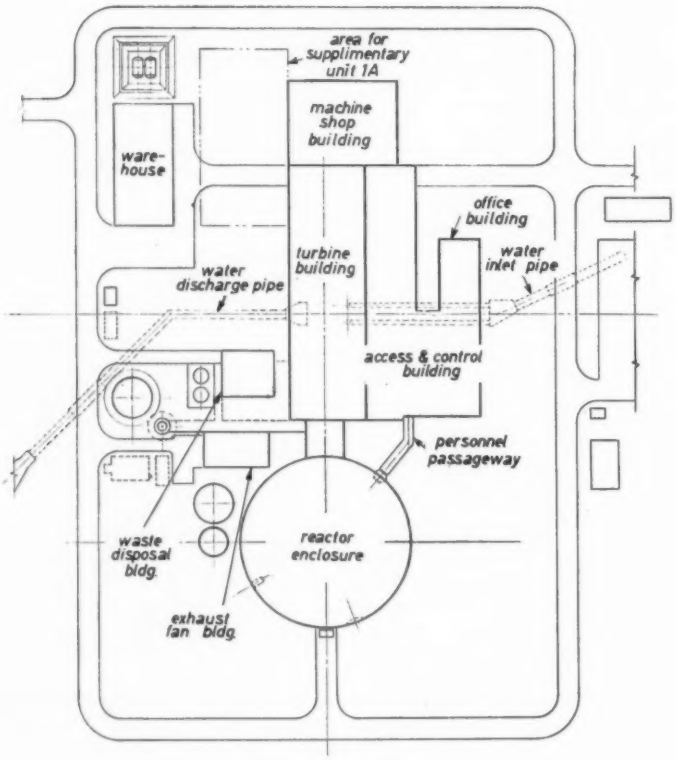
The reactor plant equipment, consisting of the reactor, a two-loop reactor re-circulating system, associated auxiliaries, and necessary shielding, are installed in the spherical containment vessel. Figure 3 indicates the general arrangement of this equipment. The main power conversion equipment and auxiliaries are installed in the turbine building, Figure 4.

System materials

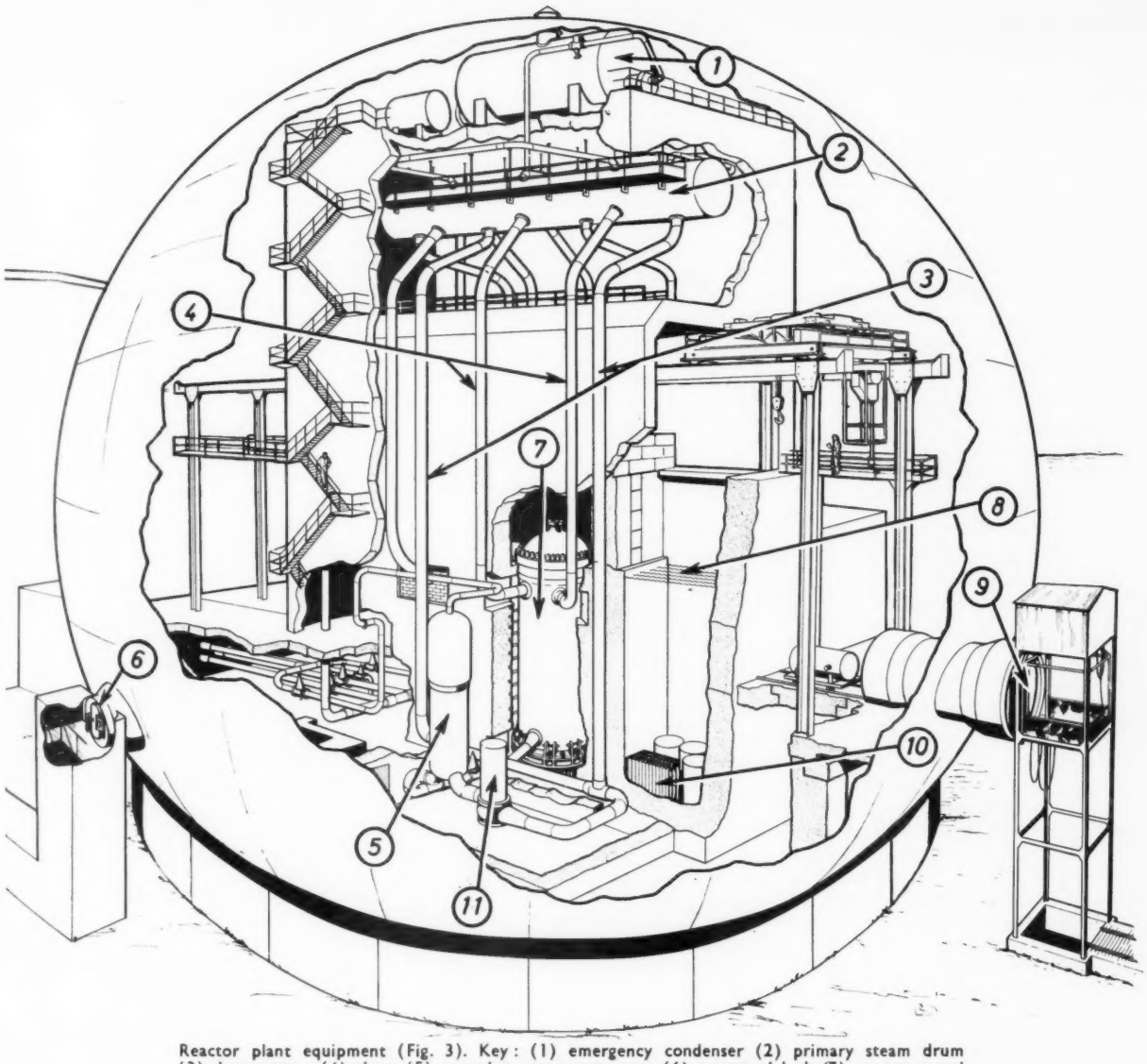
Materials used in conventional power plant construction are employed to the greatest possible extent in the Garigliano design. Carbon steel is used throughout the main steam and condensate system with a few exceptions. In most cases the turbine materials are conventional for the rated steam pressure and temperature (*3*), (*4*). Alloys of higher chromium content, however, are used in areas which are most susceptible to erosion and corrosion. In general, stainless materials are used on all surfaces in contact with the primary reactor fluid during operation. The stainless surfaces are provided by using type 304 stainless steel or carbon steel base materials clad with 304 stainless steel. The materials of each part of the system are chosen to give a plant equipment life comparable with similar equipment in a conventional power plant.

Reactor plant equipment

The reactor vessel contains the core, the core-supporting structure, the control rods, and the core instrumenta-



Plan of station (Fig. 2)



Reactor plant equipment (Fig. 3). Key: (1) emergency condenser (2) primary steam drum (3) downcomers (4) risers (5) secondary steam generator (6) personnel lock (7) reactor vessel (8) fuel storage pool (9) equipment lock (10) fuel storage rack (11) reactor circulating pump

tion. It is a cylindrical pressure vessel approximately 37 ft high and 10 ft 4 in. inside diameter with a design pressure of 1250 lb/sq in.

The reactor recirculating system consists of a single steam drum with centrifugal separators, two vertical secondary steam generators, two circulating pumps, and interconnecting circulating piping. The use of this arrangement confines any water contamination largely to the recirculating system. Contamination in the steam is held to the order of one part per billion. A bypass demineralizer system removes contaminated material from the recirculating system.

There are 68 control rods each with an individual hydraulically-operated drive mechanism to insure reliable control. Each mechanism is housed in a thimble attached to and extending below the reactor vessel. The rod control system utilizes the reactor feedwater as the hydraulic fluid. The drive mechanisms are operated independently, and the system control is so interlocked that only one control rod can be moved at a time except on reactor scram where all rods are inserted simultaneously. Insertion of control rods in the bottom of the reactor makes for better power distribution and allows for more simplified refuelling through the top of the reactor.

The major auxiliary equipment includes an emergency condenser to limit reactor temperature if other heat dissipating circuits are not available or fail; a shutdown cooling system to obtain low coolant temperature for refuelling; an emergency poison system to ensure that the reactor may be shut down and held inoperative if the normal control fails to function properly; and necessary electrical and control equipment.

Nuclear fuel and core

The core occupies an approximate cylindrical space 106·5 in. high and 115 in. in circumscribed circle diameter. It contains 384 fuel assemblies, each consisting of a square zircaloy-2 channel in which are arranged 36 fuel rods in a square array. The individual fuel rods are assembled with four segments of zircaloy-2 tubing with an outside diameter of approximately 0·56 in. The rods are filled with sintered pellets of slightly enriched uranium dioxide. The control rod poison sections are made from 2·0%

boron stainless steel plate, and are fabricated in a cross-shaped structure.

Turbine room equipment

The turbine, which is to be manufactured by Ansaldo, S.A., to General Electric design, is a tandem compound, double flow, 1500 rev/min, dual-admission unit rated at 160 MW at a back pressure of 1·25 in. of mercury. The turbine is coupled to a hydrogen-cooled generator rated at 200,000 kVA 0·8 pf, at 30 lb/sq in. hydrogen pressure. The basic design objective is to produce a turbine which, in view of the unusual conditions of using wet steam containing free hydrogen and oxygen, approaches the reliability and freedom from maintenance expected of turbines built for currently conventional steam conditions. Moisture slinger stages in the turbine and crossover keep exhaust moisture to practical operating values and reduce bucket wear. Experience in VBWR turbine operation and maintenance at the General Electric's Vallecitos Atomic Laboratory indicates that this objective should be realized.

The main condenser is a horizontal single pass, divided, water box type with a deaerating storage-type hotwell. The condenser construction and the auxiliaries are conventional except that the steam air ejector has greater flow capacity to remove the hydrogen and oxygen resulting from dissociation of water in the reactor as well as normal air leakage.

The other turbine room equipment, such as pumps, feedwater boxes, and piping, are conventional except for a full-flow condensate demineralizer between the condensate pumps and the boiler feed pumps. The condensate demineralizer assures high purity of the reactor feedwater, and permits the turbine and condenser to be made of conventional materials for the plant steam conditions.

Operating conditions

The plant is controlled from a single operating room, where all instrumentation for operation at power is located. This design feature requires a minimum number of operators per shift.

The plant areas are divided into zones of accessibility during operation. There are three main zones—a generally inaccessible zone during operation, but with controlled access during shutdown, comprising the reactor vessel, steam separator, secondary steam generators, recirculating pumps, and the associated primary piping; a controlled zone consisting of the fuel handling, control actuators and certain other areas in the reactor building and the turbine, condenser, and feedwater loop in the turbine building; and an uncontrolled zone comprising other plant auxiliary and power equipment and the control room. Equipment contained in the controlled access zones are remotely controlled. This arrangement permits operation of the plant with faulty fuel elements for a period of time until the plant is shut down and the defective elements are replaced. Operation of VBWR and EBWR has indicated that radioactive contamination of these systems from such fuel failures can be reduced to within operating limits, and that such contamination has not materially increased the plant maintenance.

A system is provided to detect and locate defective fuel elements so that plans can be made and operations scheduled for their removal during plant shutdown.

PLANT SAFEGUARDS

The principal safeguard objectives guiding the design of the station are:

1. Normal operation of the plant must not result in the exposure of any person on or off the plant premises to radiation in excess of the permissible limits; and
2. Safety protection to prevent a nuclear accident that might release radio-active materials must be conserved or maintained even in the event of equipment malfunction, operator error, or other contingencies.

The method for meeting the first of these objectives in the Garigliano plant has been the development of a system design in which there is very little radioactive material to be routinely released to unrestricted areas, and in which sources of radiation inherent in the systems are shielded to the extent necessary to minimize personnel exposure during the performance of normal operating tasks in the power plant. The approach to meeting the second of these objectives is to:

a. Design a reactor that will tend to limit power upon the start of a potentially dangerous increase.
b. Provide two separate and independent systems to shut the reactor down.
c. Provide two separate independent systems for cooling the reactor.
d. Provide multiple safety sensing devices to detect and/or prevent any potentially unsafe operating condition.
e. Design safety devices in such a way that their malfunction would shut the reactor down rather than cause or permit an increase in its power.
f. Design the control of the reactor and primary equipment to minimize the possibility of an operator error that could lead to an unsafe operating condition.

Although the possibility of a nuclear accident is extremely remote by virtue of the provisions indicated above, the reactor and associated equipment are to be housed in a vapour-tight enclosure to confine radioactive vapours that might be liberated from a reactor rupture accident, and thus prevent extensive radioactive contamination of the surroundings.

PLANT ECONOMICS

Plant cost considerations

General Electric experience has shown that capital costs for the boiling water reactor are lower than most other types of proven reactors because:

1. Steam flows directly from the reactor to the turbine, permitting elimination of expensive and space-consuming heat exchangers and an auxiliary system.
2. The use of water as a coolant is a well-known technology, allowing the use of many conventional materials.
3. Simplicity of the boiling water reactor cycle allows the design of a compact plant, saving construction time and materials.

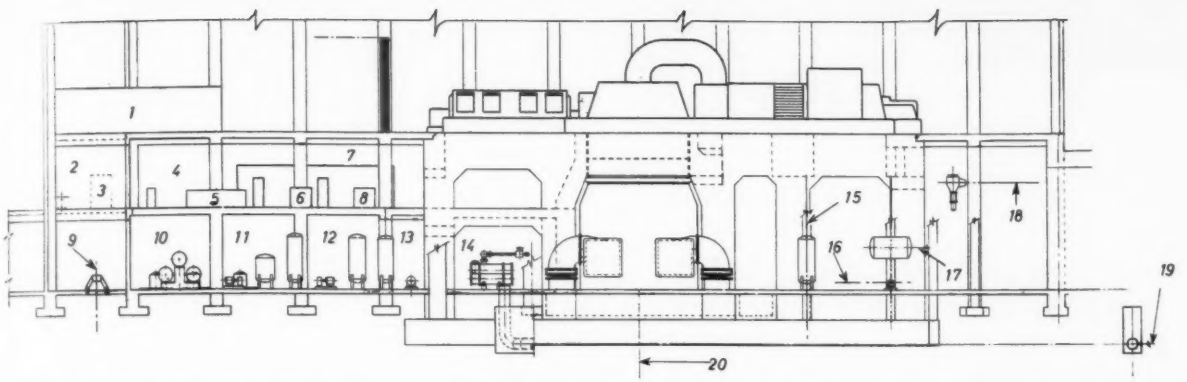
The plant cost for the Garigliano plant, including all equipment, civil works, and equipment spare parts, is approximately $295/kW (5). SENN's total first cost to put the plant into operation, including the total plant cost, interest on construction, substation, transmission lines, initial fuel fabrication cost (excluding cost of uranium), overhead expenses, and escalation, is reported to be $415/kW (6). It is planned that more than 50% of the equipment for the plant, including the turbine-generator set and condenser, will be manufactured in Italy. In addition, all skilled and unskilled labour for equipment erection and civil works construction will be supplied from Italy.

Fuel cycle cost

The fuel cycle cost for a boiling water plant of the SENN type consists essentially of six major items; i.e., fabrication, including conversion of UF_6 to UO_2, uranium depletion, plutonium credit, reprocessing cost, use charges, and shipping costs, including insurance.

Operating and maintenance costs

The annual operating cost for the Garigliano plant includes such items as manpower, supplies, administration,



Turbine building (Fig. 4). Key: (1) switchgear room (2) Battery room (3) d.c. panel (4) motor control centre no. 1 (5) spare exciter (6) exciter switchgear (7) air supply unit for turbine building (8) 380 V power centre (9) C/L R.R. car stop (10) cooling water heat exchangers and cooling water pumps (11) filter and feed pump, pressure filters and cation changers (12) anion exchangers, mixer bed exchangers and transfer pumps (13) emergency feed pump (14) air ejector (15) C/L extration by-pass flash tank (16) C/L condensate drip pump (17) C/L condensate drip tank (18) C/L secondary steam stop and control valves (19) off-gas pipe to stack (20) C/L turbine exhaust and condenser

heating and utilities, and clothing and laundry. Manpower costs are based on an operating staff of approximately 54 people working 48 hours per week. Annual maintenance costs take into consideration manpower and material, supplies, and parts. Maintenance manpower is estimated to be approximately 21 people at 48 hours per week. An approximation of the Annual Power Production costs is:

Fixed charges at 15% (based on plant cost of $295/kW)	$6,637,500
Operation and Maintenance Costs	788,047
Fuel — 12,000 MWD/s. Ton, $12/g Pu — 0·8 load factor	3,304,000
	$10,729,547

COMPARISON OF DRESDEN AND SENN

Calculated performance

Both the Dresden and SENN plants are designed with essentially the same performance characteristics. Each plant incorporates the dual-cycle system which allows load following within a specified range without movement of the control rods. In addition, each system will allow instantaneous load changes of up to 10%. The primary to secondary steam ratio for the SENN plant is approximately three times that for the Dresden station. increase in primary to secondary steam This is brought about by an increase in reactivity in voids which allow for a higher exit quality for the SENN plant. Increase in exit quality, of course, allows for a larger amount of heat to be removed from the reactor for a given reactor coolant flow rate, and also allows for an improvement in the over-all plant heat rate.

Safety

Both the Dresden and SENN plants have essentially equal safety systems for protection of plant and environs; however, the SENN plant will contain a core spray system within the reactor which will allow flooding of the core in the event of the gross loss of coolant resulting from an extreme failure in the primary system. This item provides an added measure of safety for a nuclear power plant for a small additional cost.

Simplicity

Several important improvements in layout and plant design have been made in the SENN plant as compared to Dresden. Within the primary system, the number of recirculating loops has been reduced from four in the Dresden case to two in the SENN case. This results from the change in the primary to secondary steam ratio which provides for a smaller secondary steam flow and by the change in rating between the two plants.

The SENN plant refuelling system has been incorporated entirely within the reactor containment sphere as an integral part of the reactor sphere arrangement. This allows the elimination of a separate refuelling building which has been provided for the Dresden plant. The turbine room arrangement for the SENN plant has been improved somewhat over the Dresden design by the incorporation of a full-flow condensate demineralizer with one line of feedwater heaters through which the returning feedwater flows to the primary system. This arrangement is brought about by the reduced capacity between the two plants. It has the advantage of reduced capital cost and also complete demineralization of all returning feedwater.

ORGANIZATION

The SENN plant will be built under contract with International General Electric Operations, S.A., a Swiss corporation which is a subsidiary of the General Electric Company. Work to be performed by the General Electric Company will be carried out under subcontract to International General Electric Operations, S.A. Within the General Electric Company, the reactor system engineering and over-all plant engineering will be carried out by the Atomic Power Equipment Department in San Jose, California. Ebasco Services will perform plant engineering at their offices in New York City, and supervise erection of equipment at the plant site. In order to maintain the utmost efficiency in construction of the plant, International General Electric Operations, S.A., will establish engineering coordination and procurement offices in Rome, Italy, specifically for the Garigliano plant. Coordination between the work performed under subcontract to General Electric Company and Ebasco Services with that performed by various subcontractors and equipment vendors in Italy, will be through the International General Electric Operations, S.A., offices.

References:

1. Wolcott, J. R., Elliott, V. A., Roy, G. M., Peabody, E. P., Sege, G., and Schanz, J. L. 'The Dresden nuclear power station.' *U.S. ASME Paper* No. 56-A-169, Annual Meeting, 1956
2. Elliott, V. A., Maxson, R. D., Nixon, V. D., Merryman, J. W. 'The Dresden nuclear power station,' Geneva Conference 1958, Paper 2372
3. Calatch, H. A., Cheng, C. F., and Musick, V. S. 'Investigation of erosion and corrosion of turbine materials in wet oxygenated steam,' *ASME Paper* No. 57-A-134, Annual Meeting, December 1957
4. Elston, C. W., 'First large steam turbine for operation with a boiling water reactor,' *American Power Conference*, Chicago, March, 1958
5. Matteini, C., 'Why SENN chose GE reactor,' *Nucleonics*, May, 1959, p. 95.
6. Matteini, C., 'ENSI—The facts' Letter to NUCLEAR POWER, January, 1959, p. 75.

The second article in our new series moves on from pulse amplifiers and puts into perspective recent work on the next stage in a detection system

Electronics for radiation detection

2. Discriminator and allied circuits

by F. H. WELLS, M.Sc., A.M.I.E.E.,
Electronics Division, A.E.R.E., Harwell

1. Introduction

Throughout the whole field of nuclear physics the experimental physicist is continually faced with the need for precise measurements on each of the particles or gamma quanta concerned in the reaction being studied. The main parameters to be measured are the energy and mass of the particle, the direction of travel, particle velocity, the time of occurrence and finally whether there are any other events related to this particle. For the measurement of energy, one common method is to use a detector, which will absorb most of the particle energy and produce a quantity of electrical charge proportional to this energy; the charge is transformed into a short duration voltage pulse of peak amplitude proportional to charge input by a suitable circuit. Such a counter might be an ionization chamber for alpha particles or a photomultiplier with sodium iodide scintillator for gamma quanta. We shall then require circuits for measurement of the amplitudes of the voltage pulses from the counter. Circuits which are triggered by pulses with peak amplitudes above a defined voltage level are termed amplitude discriminator circuits, whilst those which require the input pulse amplitude to be between two defined voltage levels are called single channel pulse amplitude analysers.

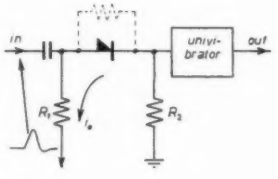
The measurement of particle mass will not concern this article, but information on the timing of the event will require the use of time discriminators. One common form is a circuit which will accept two or more pulses and give an output when the time difference between the arrival of these pulses is less than a value defined in the circuit. Such arrangements are called coincidence circuits, and the time interval defined by the circuit is termed the coincidence resolving time. These circuits may be used to relate several particles together, to define a particle track or be adapted to the measurement of the velocity of a particle.

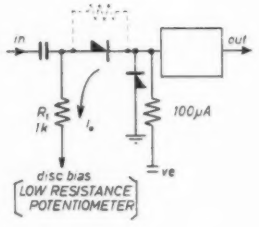
Some basic circuits for amplitude discriminators and coincidence circuits will now be described, but the description of the more complicated developments of the circuits for multi-channel-amplitude and time analysis will be left to another article.

2. Amplitude discriminators

These circuits must detect when an input voltage or current pulse has a peak amplitude greater than a given threshold value. In addition, when such a pulse occurs, the circuit must give a standard output pulse suitable for operating a scaler or other 'digital' type of circuit. The first condition is met by using a non-linear circuit element such as a diode to define the threshold level and

Typical diode discriminator (Fig 1a)





Improved diode discriminator (Fig 1b)

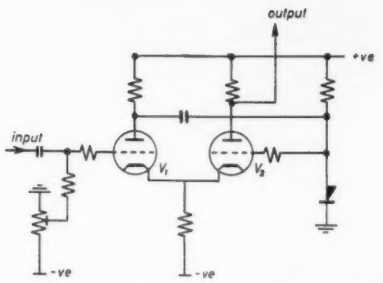
the second condition demands the use of a univibrator type circuit following this diode.

A typical diode discriminator arrangement is shown is Figure 1a, whilst Figure 1b gives an improved circuit. Germanium point contact diodes are normally used because of their 'speed' and their low anode to cathode capacity (about 1 pf). Unfortunately the resistance from anode to cathode (when biassed off) is rather low, and is of the order 100 k to 1 M, so that a small current i_0 flows as shown in Figure 1a. This current flowing through the resistors gives a small change of bias across the diode and so alters the threshold level to an input pulse. Moreover, this effect is dependent on temperature so that it is important to remove it as far as possible, and this has been done in Figure 1b. Here R_2 has been replaced by a diode which appears as a low resistance until a pulse is applied. R_1 cannot be treated in this manner because the input pulses may have both polarities; a low value of resistance (1 k) must be used. This low value of R_1 is the main disadvantage of the circuit and necessitates the input pulse being derived from a low impedance source such as a cathode follower. If this requirement cannot be met, then a thermionic diode can be used, and R_1 increased, but with the disadvantage of higher self capacity and dependence on heater voltage.

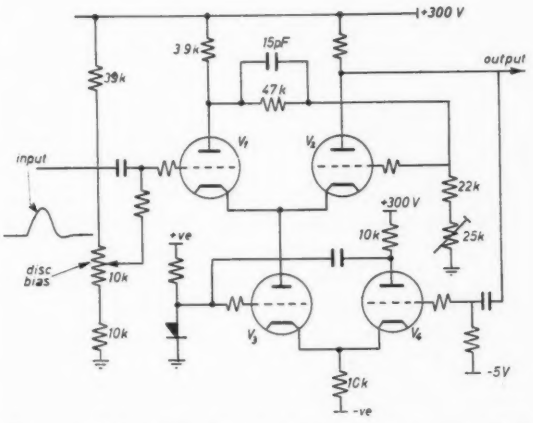
OUTLINE

Wells reviews some basic circuits for* amplitude discriminators, *including a cathode coupled univibrator, the d.c. coupled trigger circuit with controlled paralysis time, circuits for dealing with very small and very fast input pulses, and a transistorized type for operating on current pulses. He shows how two amplitude discriminators followed by gating circuits are used to form a* single channel pulse amplitude analyser *and illustrates refinements for stable narrow channel and accurate timing applications. After reviewing a* Geiger müller quench circuit, *he describes the principles of* coincidence *and anti-coincidence circuits as far as two channel slow circuits and gives a typical coincidence pulse shaping circuit and mixer.

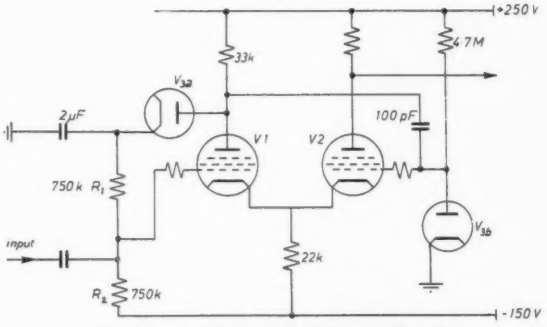
The simplest circuit to follow this diode discriminator is shown in Figure 2 and is a conventional cathode coupled univibrator circuit. The duration of this circuit must be greater than the input pulse duration, otherwise there is a possibility of self oscillation at certain critical value of input pulse amplitude. The bias on the input valve V_1 must be set to the most sensitive condition compatible with the avoidance of self oscillation and the circuit normally requires a minimum of about 5 volts of pulse for satisfactory operation. The combination of Figures 1b and 2 will typically cover an amplitude range of 5 to 55 volts. Some control of the threshold can be obtained by varying the bias on



Conventional cathode coupled univibrator circuit (Fig 2)

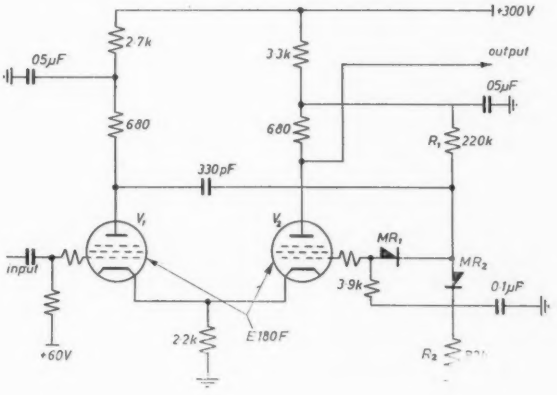


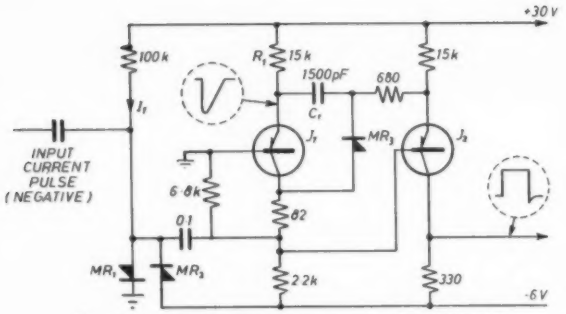
D.c. coupled amplitude discriminator with controlled paralysis time (Fig 3)



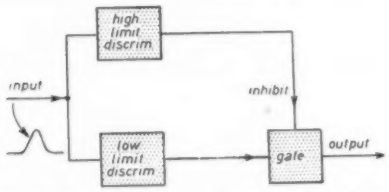
Sensitive amplitude discriminator (Fig 4)

Sensitive univibrator circuit for fast input pulses (Fig 5)

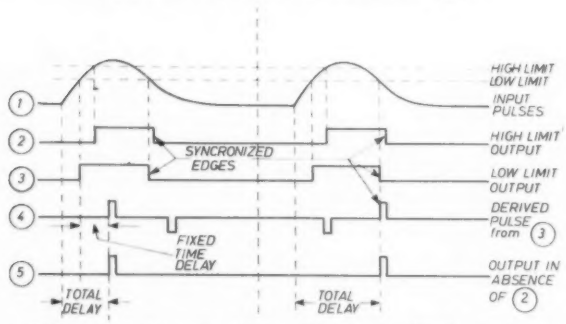




Sensitive discriminator for current pulses (Fig 6)



Single channel amplitude discriminator (Fig 7)



Gating technique in single channel amplitude analyser (Fig 8a and b)

V_1 in Figure 2, thus dispensing with the need for the diode discriminator, but this method is usually unsatisfactory because the bias has a marked effect on the duration of the circuit. In cases where the circuit must operate satisfactorily from a wide variety of input pulse durations and shapes, the circuit of Cooke-Yarborough (*1*) shown in Figure 3, may be used. This consists of a d.c. coupled trigger circuit using V_1 and V_2 together with a paralysis circuit using V_3 and V_4. The output will consist of a pulse duration equal to the duration of the circuit associated with V_3 and V_4 or the duration of the input pulse, whichever is the longer. In this case all the amplitude discrimination may be controlled by varying the bias on V_1 grid, since the output pulse duration is not affected by this bias.

The input pulses to these circuits will all be derived from an amplifier system following the radiation detector, so that the more sensitive the discriminator can be, the less the gain required in the amplifier. Figure 4 shows a sensitive discriminator circuit by Kandiah (*2*). Both valves normally pass a current whose value is determined by the d.c. negative feedback chain R_1, R_2, V_{3a}. The circuit does not oscillate because the diode impedance of V_{3a} shunts the anode load of V_1 reducing the loop gain of the circuit below unity. When a positive input pulse is applied, the current through V_{3a} is reduced and the circuit triggers when the impedance of this diode becomes sufficiently high. A threshold sensitivity of 100 mV pulse amplitude with a stability of 2% can be achieved under practical operating conditions, but the circuit has been used with input pulses as small as 5 mV. This excellent stability is obtained because the action of the circuit is largely dependent on the impedance characteristic of diode V_{3a} and this is stabilized by running the diode at constant current. An amplitude range of, say, 50 mV to 1 volt may be covered by varying the diode current, or more commonly, by preceding the circuit with a diode discriminator a range of 0·5 to 10 volts can be covered.

Circuit for very fast pulses

The circuits of Figures 2 to 4 are in common use but are not very suitable for very short duration input pulses; Figure 5 shows a sensitive univibrator circuit due to Wells (*3*) for use with very fast input pulses. Both valves normally pass a current determined by the feedback chain R_1, R_2, MR_2, but the circuit is stable because MR_1 is biassed off by about 0·5 volt. The circuit is triggered when the pulse from the anode of V_1 is sufficiently large to cause MR_1 to conduct. Thus the circuit is somewhat similar to Figure 4, but with a series diode instead of shunt diode and all circuit impedances reduced to a minimum. The input pulse threshold is about 0·5 volt and the performance for rectangular input pulses is satisfactory down to durations of 15 nanoseconds (0·015 μs).

A sensitive discriminator which will operate on a current pulse as described by Goulding (*4*) is shown in Figure 6. The transistors J_1 and J_2 pass about 2 mA each under normal conditions. The regenerative loop gain is reduced by the low impedance of diode MR_1 which is passing 300 μA. An input current pulse which reduces the diode current sufficiently to make the loop greater than unity will trigger the circuit which will then have a dead time determined by C_1 and R_1. The threshold is controlled by adjusting current I_1. The stability of the threshold is about $\pm$ 1 μA of input current. This type of circuit is particularly suitable for use wih transistor amplifiers, since they generally deliver a current pulse output.

3. Single channel pulse amplitude analyser

Two amplitude discriminator circuits are used to define the upper and lower limits of amplitude to be selected; Figure 7 shows the arrangement. A pulse from the lower discriminator is fed to the output terminal, except when the upper discriminator has also been triggered. It should be realized that the pulse from the upper discriminator will occur later than the lower discriminator, so that the subsequent gating circuit must make allowance for this rather variable delay. Figures 8a and 8b show the principles of the two methods in

use for the gating circuits, the first introducing a fixed delay between the output of the low limit discriminator and the gate by means of a delay line to offset the delay between upper and lower discriminators, whilst the second method derives suitable waveforms from the back of the input pulse as shown in Figure 8b.

Energy spectrum and timing measurements

The experimental uses of these instruments fall into two categories: —

a. *Energy spectrum measurements using a very narrow channel width such as* 1% *of maximum amplitude.* In this case the channel width must be very stable and independent of the setting of the lower amplitude discriminator. The simple arrangement of Figure 7 will not normally be satisfactory, due to instability of the thresholds of the discriminator circuits; this channel width stability is improved by the technique shown in Figure 9. A back-biassed amplifier with gain stabilized by negative feedback is used, thus allowing the two discriminator circuits to be set well apart in threshold levels so that their instabilities have a negligible effect on channel width, e.g. a typical width of 0·2 volts would require 4 volts between discriminator thresholds using an amplifier gain of 20. Farley (*5*) has described a circuit in which he uses the gating technique of Figure 8b.

b. *Timing measurements between nuclear particles of selected energy ranges* need the use of a single channel amplitude analyser in association with coincidence circuits. For this case the time delay through the analyser must be kept to a minimum and as independent of pulse amplitude as possible, but the channel width stability is not too important. Thus the arrangement of Figure 7 is used but the method of Figure 8b is inadmissible and the technique in Figure 8a must be employed. The total delay may still vary considerably, especially when the input pulse amplitude is only just sufficient to trigger the lower discriminator circuit, but this effect may be improved by the introduction of a third 'timing' discriminator with a threshold level set at about half that of the lower discriminator. Figure 10 shows the method due to Breitenberger (*6*); here the total delay equals that of the delay line plus the time delay in triggering the timing discriminator; this latter time is small and as nearly constant as the rise time of the input pulse will permit.

4. G.M. quench unit

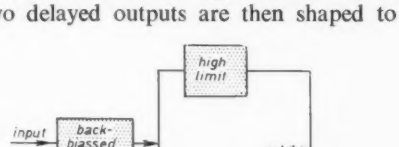
This is a special case where a sensitive trigger circuit provides a suitable pulse output as well as improving the operation of a counter. The Geiger-Müller counter gives an avalanche of electrons at the anode for each nuclear particle entering the active volume. Positive ions are also formed which drift to the cathode, where they may release electrons which in turn may initiate another counter discharge. To avoid this multiple discharge effect, it is necessary to reduce the anode voltage by about 250 volts for a period of about 300 μs following each initial pulse. Figure 11 shows the circuit designed by Cooke-Yarborough *et al* (*7*) for this purpose. Valve V_1 is just biassed off whilst V_2 is conducting and can amplify the negative input pulse. When the circuit is triggered, valve V_1 is brought into conduction, thus giving a large negative voltage swing to the anode of the G.M. tube.

5. Coincidence units

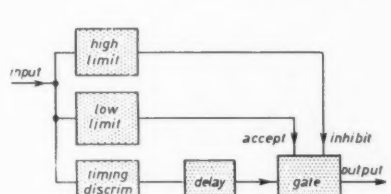
The nuclear physicist often requires to measure the time between the occurrence of nuclear particles—a typical case might be the measurement of the half life of a short lived radioactive isotope. Thus we require circuits for measuring the time between pulses from nuclear counters, or circuits for detecting when the input pulses lie within a given time interval of each other. These coincidence circuits may be designed to accept input pulses from two or more counters and the time intervals used may vary from 2 nanoseconds (0·002 μs) to 5 microseconds. We will restrict the present discussion to two-channel slow circuits and the circuit principles may be appreciated from Figures 12 and 13; faster circuits are treated by Lewis and Wells (*8*).

The input pulses are first applied to amplitude discriminators or single channel pulse amplitude analysers and the outputs of these circuits trigger variable delay circuits. The two delayed outputs are then shaped to

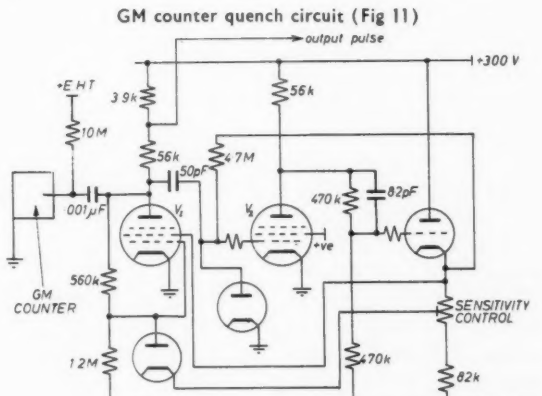
Single channel amplitude analyser (stable narrow channel application) (Fig 9)

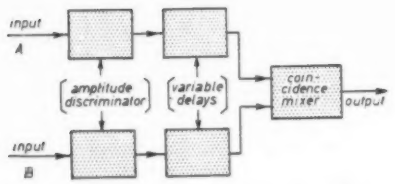


Single channel amplitude analyser (accurate timing application) (Fig 10)

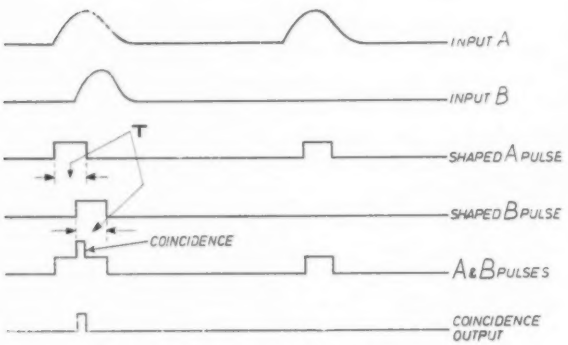


GM counter quench circuit (Fig 11)

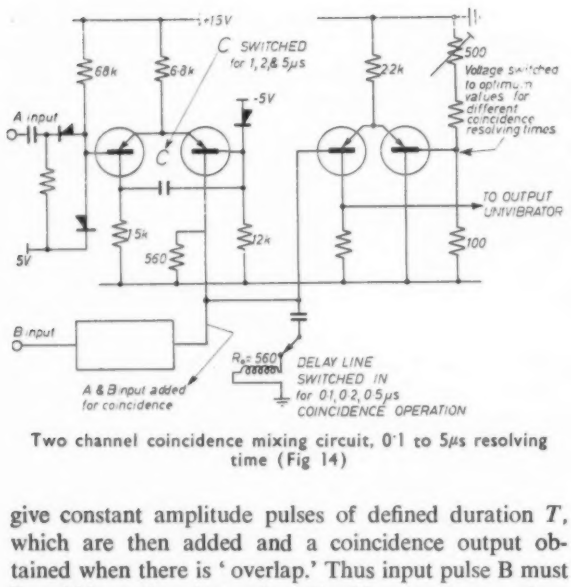




Two channel coincidence arrangement (Fig 12)



Typical coincidence circuit principle (Fig 13)



Two channel coincidence mixing circuit, 0·1 to 5μs resolving time (Fig 14)

give constant amplitude pulses of defined duration T, which are then added and a coincidence output obtained when there is 'overlap.' Thus input pulse B must lie within a time interval $\pm T$ with respect to a given delay time before or after pulse A. The value of T is termed the coincidence resolving time, and for some experiments it must be well stabilized. The settings of the variable delay circuits will depend on the experiment, the most usual requirement being to obtain zero fixed delay between A and B; the delay circuits will then be adjusted to equalize the inherent time delays of the A and B counters and the amplitude discrimination circuits.

Figure 14 shows a typical coincidence pulse shaping circuit and mixer, suitable for use in the 0·1 to 5 μs range. Transistor emitter coupled trigger circuits are used to give pulse durations of 1, 2 or 5 μs, whilst delay line pulse shaping is used for pulse durations 0·1, 0·2 and 0·5 μs. The two pulses are added together and the overlap detected by the subsequent transistor circuit.

Choice of resolving time

The choice of coincidence resolving time depends on two factors:

a. The nuclear counters and amplitude discrimination circuits introduce a variable delay time between the original nuclear event and the shaped pulse in the coincidence mixing circuit. Thus the resolving time must be made greater than these timing uncertainties.

b. There will, in general, be a background of unwanted pulses, due to unrelated nuclear particles or gamma quanta, and these will give input pulses which will occasionally occur within the coincidence resolving time. The number of such 'chance' coincidences is given by the formula

$$N_R = 2N_A N_B T$$

where N_A = input rate per second from counter A
N_B = input rate per second from counter B
N_R = chance coincidence output rate per second
T = coincidence resolving time in seconds

Thus T must be kept to a minimum consistent with requirement **a.** to reduce the chance coincidence rate. If N_R is still too high, then N_A or N_B must be reduced in the experiment.

Another similar class of circuits called anti-coincidence circuits are also needed. In this case, pulses from input A are normally fed through the unit to the output unless a pulse B arrives within a defined time interval T with respect to A pulse; in this case the output is inhibited. The time T is then termed the anti-coincidence resolving time. It should be realized that pulse B may arrive a short time after pulse A and yet be required to inhibit the output so that this gating problem is just the same as met in pulse amplitude analysers (Figure 8a); a similar circuit principle is used. Pulse amplitude selection and variable delay facilities are also required as in Figure 12.

6. Conclusion

The circuits discussed have given the reader an introduction to the principles involved. Most of the circuits use thermionic valves, since these designs have been in use for some time, but many circuits could well use the equivalent transistor configuration to advantage; this policy should be adopted for future design work in this field.

References :

1. Cooke-Yarborough, E. H. 'A new pulse amplitude discriminator circuit' *J. Sci. Inst.* 1949, *26* (March) p 96
2. Kandiah, K. 'A sensitive pulse trigger circuit with a stable threshold' *Proc. Inst. Elect. Engrs.* 1954, *101*, pt. II (June) p 239
3. Wells, F. H. 'Single channel pulse amplitude analyser type 2010B' AERE, Harwell
4. Goulding, F. S. 'Transistorization' *Nucleonics*, 1959 (June) p 64
5. Farley, F. J. M. 'A flexible single channel pulse amplitude analyser' *J. Sci. Inst.* 1954, *31* (July) p 241
6. Breitenberger, E. 'A precision single channel kicksorter for coincidence work' *Phil. Mag.* 1953, series 7 *44* (Sept) p 987
7. Cooke-Yarborough, E. H., Florida, C. D., Davey, C. N. 'An improved quench circuit for Geiger counters' *J. Sci. Inst.* 1949, *25* (April) p 124
8. Lewis, I. A. D., Wells, F. H. *Millimicrosecond Pulse Techniques* Pergamon Press Ltd., 1954

The modern approach to criticality control in plants handling fissionable materials is by inherently safe design rather than analytical control. We begin this month a two-part survey of the factors involved

Criticality problems in chemical plant design

by G. R. HALL, Ph.D.
Reader in Nuclear Technology, Chemical Engineering Department, Imperial College, London

WITH THE NEED FOR large-scale chemical operations involving fissionable materials, a new and vitally important facet of plant design has evolved—the nuclear criticality hazard—requiring the chemical engineer to have a good knowledge of nuclear physics. Until recently the designers of such plant have tended to deal with the problem by a system of precise analytical control, but now great efforts are being made to design plant which is itself inherently safe. In a discussion of this subject, it is first necessary to outline some of the basic nuclear facts.

The three fissionable materials which are used in large quantities, mainly as reactor fuels, are plutonium-239, uranium-233 and uranium-235. When a sufficient quantity of any of these is allowed to accumulate under suitable conditions a chain reaction can be set up and a criticality hazard can ensue. Such a hazard is due to the large amount of heat which is evolved in a very short period of time—this may lead to an explosive reaction—and to the large amounts of beta and gamma radiations and neutrons which will be emitted. The violence of such a reaction depends on many factors. Thus if the critical conditions are reached very rapidly and the fissionable material is contained in a confined space, then it is possible to have an explosion which could lead to widespread damage to the plant and to large areas of the factory being dangerously contaminated with radioactive fission products. It is important to appreciate that this type of explosion is only 'conventional' in size and never of atomic bomb violence. It is nevertheless highly dangerous and every conceivable precaution is taken to prevent its occurrence. At the other end of the scale it is possible that the outward signs of such an accident would not even be noticed without the aid of nuclear radiation detectors. Such an accident occurred at the Oak Ridge Y 12 plant in 1958 and lead to extensive contamination and to several plant operators receiving large overdoses of radiation.

The following is a typical fission reaction:

$$U^{235} + n \rightarrow {}_{60}Nd^{144} + {}_{39}Y^{89} + 3n$$

The uranium atom has undergone fission after collision with one neutron and the neodymium and yttrium isotopes are fission products of the reaction. Of the three new neutrons which are also produced, one is used up by maintaining a chain reaction, and the rest are captured in the surrounding materials. If a mass balance for the reaction is made, using atomic mass units, then it is found that $\triangle m$, the loss of mass during the reaction, is 0·2146 atomic mass units. This mass appears as energy and represents about 200 MeV. In more customary engineering units, this represents 28×10^9 B.t.u for every pound of uranium undergoing complete fission. Of the total energy of fission about 162 MeV is carried by the recoiling fission fragments as kinetic energy and this leads to extensive chemical decomposition of the surrounding medium. If the fissionable material is in aqueous solution and the chain reaction proceeds fast enough, the solution boils and large quantities of steam are formed. It is the rate of growth of the chain reaction which determines its explosive nature. There are a number of important factors, based largely on the nuclear characteristics of the processing equipment, that influence the reaction. These will now be briefly discussed.

FACTORS INFLUENCING SAFE DESIGN

- **mass and volume of fissionable material**
- **leakage of neutrons from the vessel surface**
- **reflection of neutrons by the surroundings**
- **effect of neutron absorbers in the solution**
- **interaction of fissionable systems**

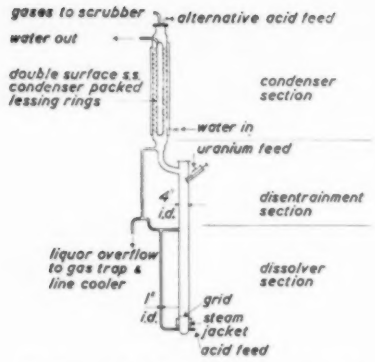
1. Mass of fissionable material

For any particular set of plant conditions the rate of growth of neutrons varies with the quantity of fissionable material and there is a certain critical mass below which it is impossible for a chain reaction to be sustained. There are also critical volumes and concentrations. Experimental data for plutonium and uranium isotopes are available for each of these factors (Table I). This means, for instance, that, in spherical geometry surrounded by an infinite water reflector, an aqueous solution containing less than 509 g

TABLE 1 *Minimum critical conditions of aqueous solutions of fissionable materials (water-reflected)*

FISSIONABLE MATERIAL	MASS (*grams*)	VOLUME (litres)	CONCENTRATION (*g/litre*)
*U-235**	790	5·2	11·6
U-233	588†	3·5	10·9
Pu-239	509	5·0	7·3

**93·5% U-235*
†*Smallest experimental figure—true minimum is probably lower*



The 'eversafe' dissolver, with a capacity of 15 litres, was designed for processing enriched uranium at the Dounreay fast reactor chemical plant (Fig. 1)

of plutonium can never become critical. Similarly a minimum volume of 5·0 litres is always safe. As we shall see, the conditions of spherical geometry together with an infinite water reflector represents the most dangerous conditions normally occurring in practice. Each of these critical constants may however be increased by a number of factors and hence safer conditions result.

2. Neutron leakage

Neutrons escape at the surface of the vessel. The shape most favourable for a minimum critical mass is therefore a sphere and larger safe volumes take the form of a thin cylinder or thin slab where there is a large surface area to volume ratio. Table 2 gives some minimum critical dimensions. Thus a 5·0 in. diameter infinitely long cylinder is always safe for plutonium solutions, whereas for an uranium-233 solution the critical diameter is 4·5 in. Similarly a slab of thickness 1·7 in. of plutonium solution is always safe. These factors assume that an infinite water reflector surrounds the system. Under normal conditions (unreflected), therefore, these critical dimensions would be larger.

TABLE 2 *Geometry control: Minimum critical dimensions for water-reflected solutions of fissionable materials*

FISSIONABLE MATERIAL	SPHERE DIAMETER cm	SPHERE DIAMETER in.	CYLINDER DIAMETER cm	CYLINDER DIAMETER in.	SLAB THICKNESS cm	SLAB THICKNESS in.
U-235 (93·5%)	21·5	8·5	13·5	5·3	3·4	1·3
U-233	18·8	7·4	11·4	4·5	1·4	0·5
Pu-239	21·2	8·3	12·7	5·0	4·3	1·7

This table is only valid provided the densities of the fissionable isotopes do not exceed the following values:

H/U RATIO	MAXIMUM URANIUM DENSITY g/litre
5	2·7
10	1·8
20	1·00
50	0·48
100	0·25
200	0·13
500	0·052
1000	0·026

The critical cylinder and slab dimensions are of great importance in the design of geometrically safe plant. An 'eversafe' dissolver unit (Figure 1) using a 4 in. column has been described by Buck *et al* (*1*) and was developed for the processing of enriched uranium in the Fast Reactor Chemical Plant at Dounreay. Mixer-settler units shaped in the form of slabs only 3 in. in height have been calculated to be safe for fissionable materials in concentration up to 400 g/l of solution. Similarly a geometrically safe solvent washer in the form of a cylinder 7 in. in diameter and 12 ft high has been described by Colven (*2*). Both these latter equipments have been used in a layout in which a continuous washer is coupled directly to two mixer-settler units in a closed circuit with 100 gal of solvent. Such facilities are being developed for the processing of 1 tonne of uranium per day in nitric acid solution feed. Whilst this type of equipment may be small in dimensions it is usually necessary to space units well apart from each other and to ensure that each unit is not near to any neutron reflectors which may alter the geometric safety of the layout (next section).

3. Neutron reflection

If the fissionable material is surrounded by a substance which reflects neutrons back into the system, then the neutron leakage is reduced and the critical factors become smaller. A reflection coefficient known as the albedo (ratio of outgoing neutrons to incoming neutrons) is commonly used to describe the reflection properties of constructional materials. These have been measured for common materials such as concrete, steel, aluminium, water etc. and it is found that 16 in. of any of them surrounding a source of neutrons can reflect over 80% of all the outgoing neutrons back to the source. It is thus most important to assess the reflection characteristics of the equipment surrounding any vessels holding fissionable material in a chemical plant. This is difficult especially when it is appreciated that even the presence of a human body can cause an increase in the reflection and moderation of neutrons.

Graves and Paxton (*3*) have measured the critical masses for spheres of 93·5% uranium-235 metal with a variety of surrounding reflectors (Table 3). An isolated sphere of this uranium has a critical mass of 51·9 kg (Table 4), whereas if surrounded by a thick reflector of such materials as aluminium, iron or water the critical mass is reduced by approximately a half. It may be appreciated that flooding of a plant handling enriched uranium metal or plutonium metal could result in a complete change in the critical constants for the various storage vessels, due to the addition of an efficient reflecting and moderating medium. Graves and Paxton have discussed the variation of critical mass of water flooded lattices of enriched uranium. They show how the critical mass decreases from 22·8 kg for a single sphere, to about 12 kg for a lattice of $\frac{1}{2}$ in. cubes of uranium metal, to about 6 kg for a lattice of $\frac{1}{8}$ in. uranium rods, and down to less than 2 kg for machine turnings. In fact the critical mass of fine turnings or loose coils of fine wire in water or oil is close to the critical mass of uranium in aqueous solution. Table 5 gives the 'safe' dimensions for cylinders and slabs of uranium-233, uranium-235 and plutonium-239. It should be emphasised that these are *safe* not *critical* dimensions *i.e.* a safety factor

TABLE 3 *Critical masses of uranium-235 spheres with various reflectors*

REFLECTOR	DENSITY g/cm³	REFLECTOR THICKNESS 1 in.	2 in.	4 in.	infinite
BeO	2·69	—	21·3	15·5	~8·9
U	19·0	30·8	23·5	18·4	16·1
W-alloy	17·4	31·2	24·1	19·4	—
H_2O	—	—	~24	22·9	22·8
D_2O	—	—	(27)	21·0	~13·6
Graphite	1·69	35·5	29·5	24·2	~16·7
Fe	7·87	36·0	29·3	25·3	23·2
Al	2·70	39·3	(35·5)	(32)	<30·0

These figures refer to uranium-235 (93·5%) of density 18·8 g/cm³

TABLE 4 *Minimum critical mass of isolated metal spheres, no moderators*

REFLECTOR	U-235 (93·5%) kg	Pu-239 kg
None	51·9	15·7*
*Water**	24·4	8·0
Metal density	18·8	15·8

**Effectively infinite reflector*
U-233 (density 18·5 g/cm³) critical masses stated to be 'nearly identical with those of plutonium'

TABLE 5 *Safe dimensions for metals, water-reflected*

FISSIONABLE MATERIAL	MASS kg	SAFE CYLINDER DIAMETER cm	SAFE CYLINDER DIAMETER in.	SAFE SLAB THICKNESS cm	SAFE SLAB THICKNESS in.
U-235	11·0	6·3	2·5	1·6	0·6
*Pu-239**	2·6	3·6	1·4	0·5	0·2
U-233	3·0	3·8	1·5	0·5	0·2

Uranium at 'full density'
**Pu metal density 19·6 g/cm³*
NOTE: *safe not critical—factor of safety of at least 2 has been applied to critical mass figures*

has been applied to the critical dimensions. This data is of particular importance when considering the storage of fissionable materials as metals.

4. Effects of neutron absorbers

The fissionable nucleus absorbs neutrons both to undergo fission and also to form a new isotope.

e.g. $Pu^{239} \xrightarrow{(n, \gamma)} Pu^{240}$

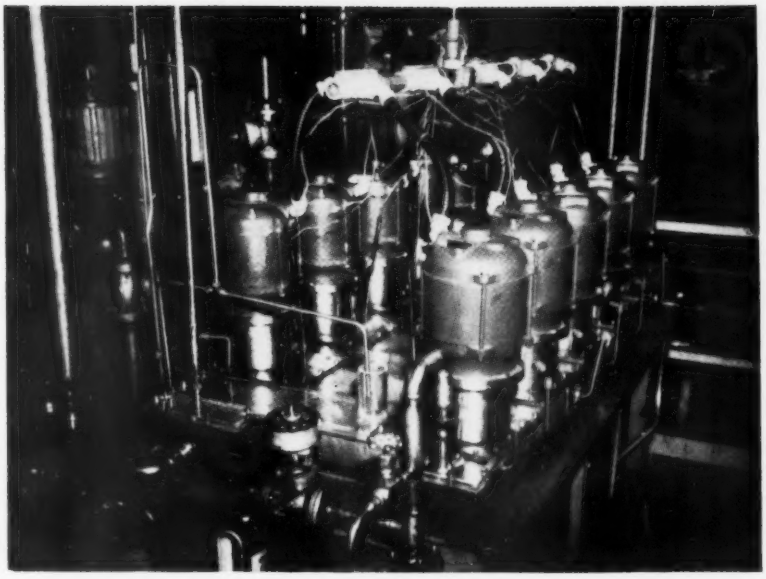
The absorption is strongly dependent on the energy of the neutrons: slow or thermal particles have a much greater probability of capture than fast ones. The neutrons produced at the time of fission are of high energy and hence, if there is a large amount of moderating materials in the system, the neutrons are rapidly slowed and there is an increased chance of capture. These considerations also apply to non-productive capture—the production of plutonium-240 is an example of this. Elements such as boron and cadmium have very large cross-sections for slow neutrons and in fact they are sometimes used in chemical plant to remove neutrons and increase the critical safety of the plant. In plant solutions the effect of all atoms must be taken into account in assessing the critical quantities for a particular system.

Another form of poison which must not be neglected is the possible presence of other isotopes of the fissionable element which may not have large fission cross-sections but have appreciable capture cross-sections e.g. uranium-238 in uranium-235.

5. Interaction of fissionable systems

Most of this discussion has been in general terms and has referred to isolated fissionable systems, although attention has been drawn to the fact that various constructional materials may absorb, reflect or moderate neutrons and hence that the environment of the fissionable system is important. In a chemical plant, where there may be many pipes, containers and reactant vessels containing fissionable material, it is also essential to consider possible interaction of neutrons from one unit on adjacent units. Each may be a source of neutrons and, whilst each may be designed to be critically safe, it may be possible for neutrons leaking from a number of adjacent pipes to make one unit critical. This hazard may be overcome by suitable spacing of all equipment although this may require uneconomically large areas of space, or by using neutron absorbers placed between units.

Interaction of neutrons is one of the very important factors to be considered in the design of storage facilities and the transport of fissionable materials.



This safe design slab mixer-settler was developed at the AEC Savannah River Laboratories for handling enriched uranium solutions. A ten-stage unit, it has a hold-up of 2 gallons per stage

METHODS OF CONTROL

There are two principle methods of criticality control. The first depends on administration and the second primarily on the design of geometrically safe plant. The former has been used in all the earlier plants designed for the processing of enriched uranium fuels, both before and after irradiation, and for the separation of plutonium from irradiated natural uranium fuels. Advantage may be taken of the minimum critical quantities, with suitable large safety factors, of the use of neutron monitors positioned around the plant to indicate any undue buildup of fissionable materials, of the use of neutron poisons and of extreme analytical control. The result is a plant which requires a very large, well-trained team of analysts and process workers, and too much emphasis is then placed on the personal element. That the system has operated so successfully is due to the well planned methods of control which have been evolved, but this has been achieved at great financial expense and at decreased process efficiency.

The design of plants which are geometrically safe has depended on the gradual accumulation of the type of data discussed above and also on the necessity for processing large quantities of pure fissionable materials such as are used in the fast reactor or in highly enriched uranium reactors. Even when extreme care has been taken in the design of vessels, pipes, and other equipment, there is still a necessity for good administrative control. There is, after all, the chance that a pipe may leak and that fissionable material may then accumulate under unsafe conditions. The plant operator must always be looking for such an eventuality and be aware of the consequences of one careless action.

McLendon (*4*), in discussing such dangers in a paper he presented at a conference held at the Vallecitos Atomic Laboratory on June 6, 1958, pointed out the dangers of using an 'unsafe' container in a geometrically safe plant. Fortunately, he claimed, there had not been at that time a criticality accident in a production factory. Yet the following week an accident of this sort occurred at Oak Ridge, where a 55 gallon drum was used to collect washings in the Y12 plant. A very complete record of a court of enquiry into the incident has been published and will be discussed in the second article.

Papers by Nicholls and Gillieson (*5*) and Callihan (*6*) should be consulted for a further discussion of criticality hazards in nuclear chemical plant design.

References :

1. Buck, C. *et al Geneva Conference 1958*, Paper 82
2. Colven, T. J. *Geneva Conference 1958*, Paper 518
3. Graves, G. A. and Paxton, H. C. *Nucleonics*, 1957, *15*, p 90
4. McLendon, J. D. *Oak Ridge Report* Y-1245, 1959
5. Nicholls, C. M. and Gillieson, A. H. C. P. *Trans. Inst. Chem. Eng.*, 1958, *36*, p 365
6. Callihan, A. D. *Nucleonics*, 1956, *14*, p 40

Acknowledgment :

The author is particularly indebted to Dr. C. M. Nicholls, of the Atomic Energy Research Establishment, Harwell, for providing the more recent critical data in Tables 1, 2, 4 and 5. These are taken from tables to appear in the chapter 'Criticality' by C. M. Nicholls, E. R. Woodcock and A. H. Gillieson in a forthcoming book entitled *Chemical Processing of Reactor Fuels* to be published by Academic Press Inc., New York.

Recent work on improving the corrosion resistance of aluminium alloys makes them an attractive possibility for both fuel cans and pressure vessels

Aluminium alloys for water-cooled reactors

by J. B. COTTON, A.M.C.T., A.R.I.C.
Head of Corrosion Section, Research Department, Imperial Chemical Industries Ltd., Metals Division

ALUMINIUM CAN PRESENT A STRONG CLAIM for precedence among the metals suitable for use in water-cooled nuclear reactors. Its alloys are reasonably strong and relatively cheap; they can be hot extruded, cold impact extruded and easily manipulated; in general they have good welding properties and above all they have the vital prerequisite of good transparency to neutrons.

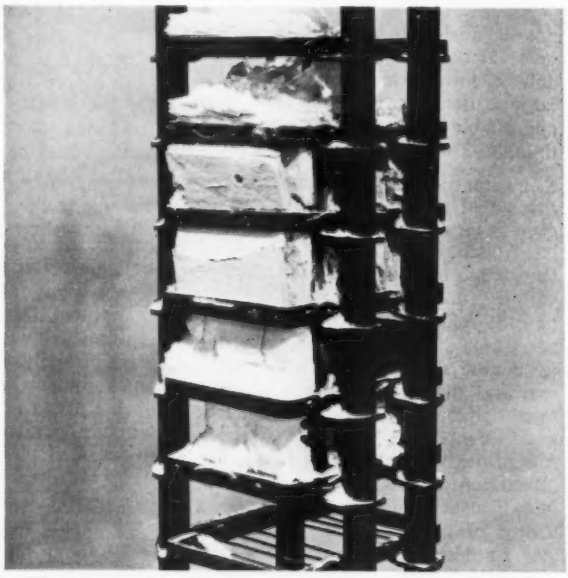
When the economic aspect is taken into account, there is clearly a strong incentive to turn to an aluminium alloy not only for fuel cans, but also for the construction of pressure vessels and ancillary equipment employed in the water circuit. Precautions can be taken to ensure compatibility with the fuel (*1*) and it is only in the further essential requirement of corrosion resistance to the coolant that it is necessary to look for improvement. It is not surprising therefore that research into means of improving corrosion resistance of aluminium has been vigorously prosecuted in those countries likely to invest in water cooled reactors.

Severe corrosion above 200°C

The necessity to depart from well tried commercially available aluminium alloys arose because it was evident that while, in general, conventional aluminium base materials are quite resistant to corrosion in pure water at more normal temperatures, the situation is completely changed at 200°C. At this temperature and above it, catastrophic corrosion of aluminium takes place and thick aluminium sections are rapidly converted by a process of exfoliation and blistering into a white flaking mass of aluminium oxide. Figure 1 shows the condition of aluminium specimens of commercial purity originally $\frac{1}{8}$ in. thick after immersion for 14 days in deionized water at a temperature of 350°C. The purer the aluminium the more catastrophic the effect, and Figure 2 shows intergranular penetration of annealed aluminium of 99·99% purity exposed to deionized water at a temperature of only 85°C.

About 1953, systematic investigation into means of avoiding corrosion of aluminium at these elevated temperatures began almost simultaneously in America, in Great Britain and elsewhere. It was reasoned that hydrogen atoms produced in a reaction between aluminium and high temperature water can penetrate into the metal lattice, collect at structural defects, and combine to form molecular hydrogen. This generates sufficient pressure to blister the surface, and then penetration of water into the blister results in rapid aqueous oxidation of the metal. More hydrogen is produced and the process is self-sustaining until the stage illustrated in Figure 1 is reached.

It is reasonable to postulate that hydrogen penetration into the metal can be prevented by providing localized regions at the metal surface at which easy discharge of hydrogen ions to gaseous hydrogen could take place. Nickel is one element capable of bringing about easy discharge of hydrogen, and in America, Draley and Ruther (*2*) showed that if nickel sulphate were added to the water, metallic nickel, precipitating at the surface of aluminium, could function in this manner and prevent rapid disintegration of aluminium. A more convenient and acceptable way of achieving the same result is to add the selected



After immersion for 14 days in pure water at 360°C. aluminium specimens of commercial purity were converted into a white flaking mass of aluminium oxide (× ½) (Fig. 1)

alloying element to aluminium so as to form a well dispersed binary second phase.

Elements capable of functioning in the prescribed manner are nickel, iron, copper, cobalt and the platinum group of metals, but when added singly to aluminium in reasonable quantities—say up to 2%—none is completely effective. Optimum protection against blistering has in fact been obtained with formulations containing both nickel and iron. Figure 3 shows the condition of specimens of

such alloys upon removal from an autoclave in which they have been subjected to the action of deionized water for 14 days at a temperature of 360°C. The degree of improvement achieved by addition of nickel and iron to aluminium can be judged by comparison with Figure 1. It is with this step forward that the practicability of employing aluminium base alloys in the construction of water-cooled reactors is significantly advanced.

In contact with water at high temperatures, many metals suffer some overall attack which makes itself evident as a slowly thickening surface film of oxide. Aluminium is no exception to this, and even when catastrophic hydrogen blistering has been avoided, it is necessary to improve corrosion resistance by further additions to the basic aluminium-nickel-iron alloy. Silicon in quantities up to, but not exceeding 0·2%, is said to be effective, but other elements favoured are titanium, beryllium and zirconium.

DIGEST

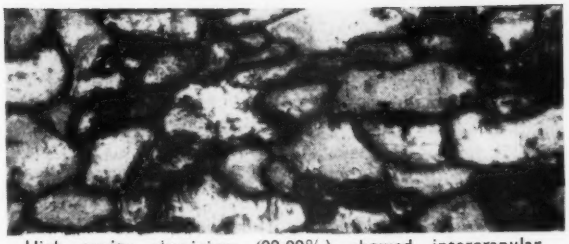
At temperatures above 200°C commercially available alloys suffer catastrophic corrosion due to hydrogen penetration into the metal, but a number of new alloys developed in Britain and overseas show greatly improved properties. They are basically aluminium-iron-nickel with additions of silicon, titanium, beryllium or zirconium. Two of them used in research reactors in operation in the USA and USSR have behaved satisfactorily.

These additions probably function by hindering transfer of aluminium ions and by helping to render the surface film impervious to penetration by either hydrogen or oxygen, but there is at least one further favourable mechanism which could operate. Thus it is known that under the influence of an impressed electrical field, dense adherent surface films can be formed upon aluminium. The well-known process of anodizing may be regarded as one manifestation of this mechanism. It now seems possible that when aluminium is immersed in high temperature water, the presence of a galvanic couple such as could exist between the aluminium-nickel phase and the aluminium matrix could result in the formation of compact films which can confer enhanced protection at least under static conditions. That such films can form at low electrical intensities has been demonstrated using impressed current methods, by Draley and Ruther in the United States (*2*), by Wilkins (*3*) in Great Britain and by Videm (*4*) in Norway.

Four 'Aereal' alloys show promise

Whatever the mechanism of protection, several alloys have been proposed which show promise of meeting corrosion requirements. In Great Britain (*3*) these alloys are known under the name of 'Aereal' and four such alloys have been specified, all based on aluminium of 99·99% purity. They are: aluminium, 2·5% nickel, 0·4% iron, 0·2% silicon: aluminium, 0·75% nickel, 0·75% iron, 0·05% silicon (max.): aluminium, 1·75% nickel, 0·75% iron, 0·15–0·3% titanium, 0·005–0·05% beryllium: aluminium, 1·75% nickel, 0·75% iron, 0·15–0·2% silicon, 0·15–0·3% titanium, 0·005%–0·05% beryllium.

In the United States (*5*) one well-established alloy contains aluminium, 1·0% nickel, 0·5% iron, 0·1-0·3% silicon and 0·1% copper, while another alloy containing aluminium, 1·0% nickel, 0·1% titanium is said to give superior performance. In Canada (*6*) alloys containing aluminium, 1–2% nickel, 0·5% iron, 0·2% silicon, 0·04% beryllium, 0·07% zirconium and 0·2% titanium have given good results. In France (*7*) alloys containing aluminium, 1·0-1·5% nickel, 1·0% iron, 0·5–0·1% zirconium and 0·5–0·1% titanium are thought to be the best. In Russia (*8*) an alloy consisting of aluminium, 1% nickel, 9% silicon is reported to have behaved satisfactorily for 6500 hours at 300°C.

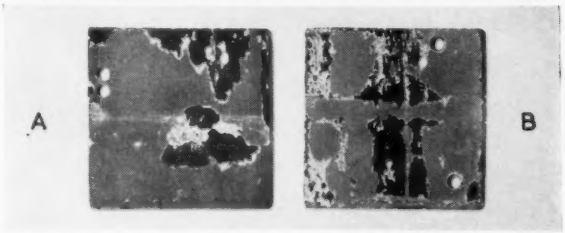


High purity aluminium (99·99%) showed intergranular corrosion after exposure to pure water at 85°C (× 140) (Fig. 2)

Effect of water flow

Performance data so far reported are virtually confined to tests operated under static conditions in autoclaves. A somewhat different picture is seen when the same alloys are used in a test loop within or without a reactor, with water flowing at speeds of the order of 20 feet per second, a water speed at which it is proposed to extract heat from the core. Results reported by various workers have differed widely, but almost invariably corrosion rates have been significantly higher than those obtained under static conditions in autoclaves. This disappointing feature obviously requires explanation and eventual correction.

Attack under dynamic flow conditions almost invariably takes the form of a general surface reaction resulting in the production of hydrated oxide films, followed by spalling, erosion or dissolution of them. Apart from water movement per se, the most signficant difference between static and dynamic conditions is that, in small autoclaves,



Appearance of aluminium alloys after exposure to pure water for 14 days at 360°C
a. Al, 2·5% Ni, 0·1% Fe, 0·07% Si
b. Al, 0·75% Ni, 0·75% Fe, 0·05% Si (Fig. 3)

the water can fairly rapidly become saturated with dissolved alumina and this could well suppress the rate of reaction at the metal surface. This effect is more noticeable where the ratio of surface area of exposed aluminium to the volume of water is high. In contrast to this, where water in contact with the specimen is continually replenished and where the ratio of surface area of exposed aluminium to volume of water is low, there is only a slow build up of soluble alumina in the water and in water depleted of soluble alumina there will be a fairly rapid

surface reaction. In any event, surface films formed under conditions of rapid flow will tend to suffer continual erosion and there will be less stifling of the corrosion reaction. The difference in reaction between deionized water saturated with alumina and similar water deficient in alumina had in fact been observed at ICI, Metals Division, in 1954 during experimental work concerned with the reaction between deionized water and aluminium under dynamic conditions at a temperature of 80°C (*9*).

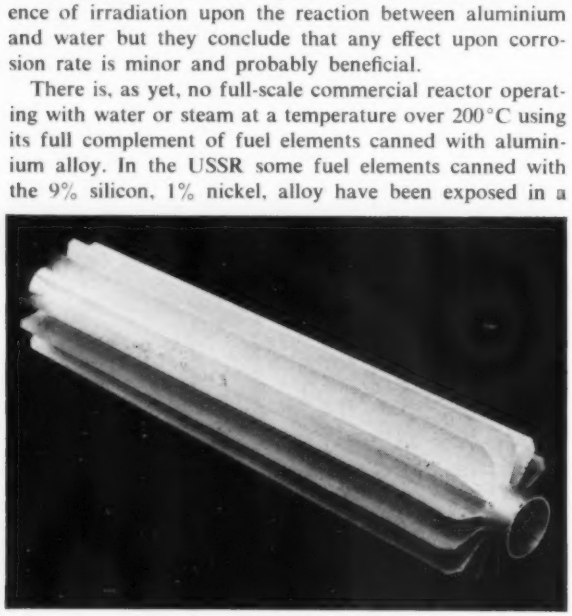
The beneficial effect of employing water containing dissolved alumina has been confirmed in dynamic tests in which water was deliberately pre-saturated with respect to alumina. For example, Krenz (*6*) reports corrosion rates to be reduced by a factor of five by this means and Ayres, Dillon and Lobsinger (*10*) have also recorded substantial beneficial effects. The last mentioned investigators, however, suggest that it may be difficult to obtain adequate pre-saturation at the working temperature of fuel cans.

Possible use of inhibitors

The evidence that the presence of dissolved alumina in water could influence the rate of reaction suggests that it might be possible to make use of inhibitors to suppress corrosion under conditions of flow. Lobsinger at Hanford and Draley at Argonne have found significantly lower corrosion rates by adding phosphoric acid to the water such that the pH value is brought within the pH range 3·8–4·5. Krenz at Chalk River has produced evidence that silica additions might also be of benefit.

Draley (*5*) and his colleagues have examined the influence of irradiation upon the reaction between aluminium and water but they conclude that any effect upon corrosion rate is minor and probably beneficial.

There is, as yet, no full-scale commercial reactor operating with water or steam at a temperature over 200°C using its full complement of fuel elements canned with aluminium alloy. In the USSR some fuel elements canned with the 9% silicon, 1% nickel, alloy have been exposed in a



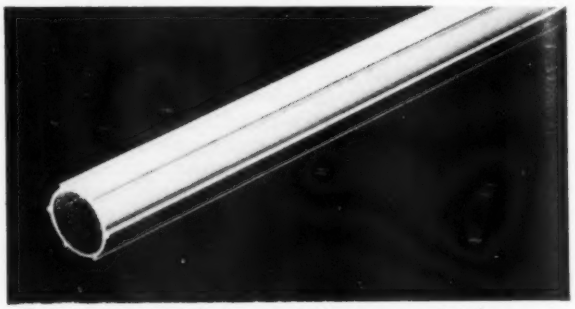
Impact extruded, deep finned sheaths in aluminium of commercial purity were produced in quantity for the Windscale reactors (× ½) (Fig. 4)

water cooled reactor at a temperature of 275°C over a period of nine months, and these were in excellent condition when removed.

Draley and his colleagues report that fuel elements sheathed in aluminium, 1·0% nickel, 0·5% iron, 0·1– 0·3% silicon and 0·1% copper have produced steam at 217°C over a period of 300 megawatt days in the experimental reactor Borax IV and that, in another experimental reactor at Argonne, corrosion behaviour of plates of this alloy was satisfactory after fifteen months' operation, during which the reactor produced steam at 250°C. There is thus sufficient justification for the interest still being shown in aluminium alloys.

Lines of improvement

The alloys so far suggested are, no doubt, capable of further development. Improvement could probably be made in the attainment of more finely divided and more evenly dispersed phases of aluminium-nickel and aluminium-iron, and this, together with use of modern metallurgical techniques such as vacuum melting, might be of some benefit. As experience in the performance of these alloys



Typical experimental sheath cold impact extruded from an Aereal alloy by ICI (Fig. 5)

in high temperature water accumulates, it is quite possible that they could be employed in a commercial reactor, particularly if, as a result of further research, a small additional increase in corrosion resistance of the alloy were achieved, or the water condition suitably modified. If and when this position arises, construction of the necessary plant should not present any great difficulty. Methods of fabrication of massive aluminium equipment are well established and aluminium alloys are already being employed in full-scale pure-water circuits at lower temperatures. Basic information concerning production of fuel sheaths also exists. Indeed, the fuel sheaths used in the first experimental gas-cooled piles, Gleep and Bepo at Harwell, were of commercial purity aluminium, as were also the deep finned sheaths employed at Windscale. The history of fuel sheath production has been adequately recorded elsewhere (*11*) and it may be sufficient here to indicate in Figure 4 one of the types of sheath that have been produced in quantity at the Metals Division of ICI using techniques of cold impact extrusion developed after many years of research. Finally, Figure 5 shows an experimental sheath cold impact extruded from an Aereal alloy.

References :

1. Wyatt, L. M., ' The production of reactor fuel elements ' NUCLEAR POWER, 1956, *1* (1, 2 and 3)
2. Draley, J. E. and Ruther, W. E., ' Corrosion resistant aluminium above 200°C ' *Argonne Nat. Lab. Report* No. AN 5430, July, 1955: also ' Aqueous corrosion of aluminium ' *Corrosion*, 1956, *12*, 441t, 480t
3. Huddle, R. A. O. and Wilkins, M. J. M., *A.E.R.E.* M/R 1669A. B.P. 812985
4. Videm, Ketil *Geneva Conference 1958*, Paper A/Conf 15/P/767
5. Draley, J. E., *et al.*, *Geneva Conference 1958*, Paper A/Conf 15/P/714
6. Krenz, F. H., *et al.*, *Geneva Conference 1958*, Paper A/Conf 15/P/194
7. Coriou, H., *et al.*, *Geneva Conference 1958*, Paper A/Conf 15/P/1271
8. Ambartsumyan, R. S., *et al.*, *Geneva Conference 1958*, Paper A/Conf 15/P/2196
9. Cotton, J. B. and Thirsk, R. F., ' Behaviour of aluminium alloys in demineralised water ' *A.E.R.E. Report* X/R 1574
10. Ayres, J. A., Dillon, R. L. and Lobsinger, R. J., *Geneva Conference 1958*, Paper A/Conf 15/P/1430
11. Smith, S. S. and Hawtin, L. R., *New Scientist*, 1958, *3*, No. 75

Reactors

Diffusion theory boundary conditions

by A. JEFFREY, M.Sc.
Senior Mathematician, Rolls-Royce Ltd.

THE BEHAVIOUR of mono-energetic neutrons in a medium with isotropic scattering and distributed neutron sources is characterized by the one group neutron transport equation

$$\Omega \cdot \mathbf{grad}\ \psi + \psi/l = \frac{c}{4\pi l} \int\int \psi(\mathbf{r},\Omega')\mathrm{d}\Omega' + s(\mathbf{r},\Omega) \qquad (1)$$

where Ω is the unit vector in the direction of neutron motion
$\mathbf{r}$ is the position vector of a neutron
s is the angular distribution of neutron sources
l is the total mean free path
$\psi(\mathbf{r},\Omega')$ is the flux of neutrons per unit solid angle in the direction Ω' at point $\mathbf{r}$

$c = \dfrac{\Sigma_s}{\Sigma_a + \Sigma_s}$ is the mean number of secondary neutrons per collision

Σ_s is the macroscopic scattering cross-section
Σ_a is the macroscopic absorption cross-section

It will be recalled that, provided the constant cross-section approximation is valid in the situation under consideration and the geometrical dimensions of the system are large compared with the mean free path, the integro-differential equation (1) may be replaced by a simpler differential equation which is valid at points well removed from sources and boundaries. A detailed evaluation of the situation and of the diffusion theory approximation in general is contained in (*1*). The diffusion theory approximation in the one group case has the well known differential equation

$$D\,\nabla^2\rho - \Sigma_a\rho + S = 0 \qquad (2)$$

where D is the diffusion coefficient
S is the neutron source per cm³ per sec
and ρ is the neutron flux.

We rewrite equation (2) as follows, introducing the diffusion length L

$$\nabla^2\rho - \frac{1}{L^2}\rho + S' = 0 \qquad (3)$$

where we make use of the elementary diffusion theory approximate expressions for D and L:

$$D = \frac{1}{3(\Sigma_a + \Sigma_s)}$$

$$\frac{1}{L^2} = 3\Sigma_a(\Sigma_a + \Sigma_s)$$

or, alternatively, introducing c,

$$\frac{l^2}{L^2} = 3(1-c)$$

The diffusion theory expression for the net current $\mathbf{j}$ in a positive direction is

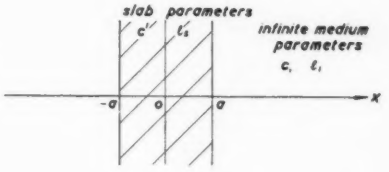
$$\mathbf{j} = -D\,\mathbf{grad}\,\rho$$

where ρ is a solution to equation (3) subject to certain boundary conditions.

We now consider the form of boundary condition that should be used in conjunction with equation (3) in order that the diffusion theory approximation may be used in situations where it would not normally be valid. Such situations occur when dealing with materials of large macroscopic absorption cross-section, close to heavy absorbers and at free surfaces bounded by a vacuum. To deal with these situations the concept of linear extrapolation length has been introduced and developed at considerable length. The full details of the analysis applied to simple geometrical configurations and yielding exact results are to be found in (*1*) while a review of diffusion theory boundary conditions is to be found in (*2*).

Results applicable to elementary configurations may, under certain conditions, be used to obtain solutions to more difficult problems. The neutron transport flux $\rho(\mathbf{r})$ is related to $\psi(\mathbf{r},\Omega')$, the vector flux of neutrons in equation (1), by the expression

$$\rho(\mathbf{r}) = \int\int \psi(\mathbf{r},\Omega')\mathrm{d}\Omega'$$



Slab of scattering and absorbing material in an infinite medium (Fig. 1)

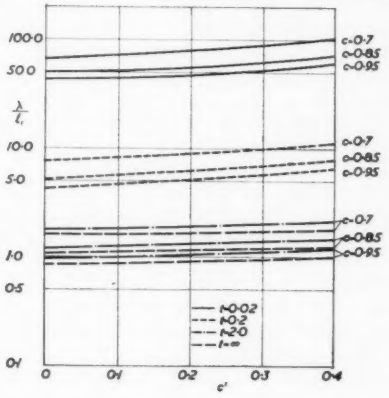
and the neutron transport current $\mathbf{j}(\mathbf{r})$ is given by

$$\mathbf{j}(\mathbf{r}) = \int\int \Omega'\psi(\mathbf{r},\Omega')\mathrm{d}\Omega'$$

If equation (1) is converted to integral equation form and examined for asymptotic behaviour it may be established that $\rho(\mathbf{r})$ is of the form

$$\rho(\mathbf{r}) = \rho_{asy}(\mathbf{r}) + \rho_{tr}(\mathbf{r})$$

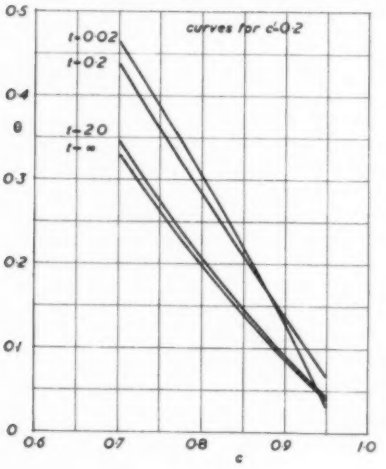
The first component $\rho_{asy}(\mathbf{r})$ is the asymptotic neutron flux and $\rho_{tr}(\mathbf{r})$ the transport correction term. When dealing



Variation of linear extrapolation length with slab and medium parameters (Fig. 2)

with infinite or semi-infinite media $\rho_{tr}(\mathbf{r})$ is only significant near boundaries being $0[\exp(-|\mathbf{r}|/l)]$ for large $\mathbf{r}$. Diffusion theory boundary conditions applicable to simple configurations are obtained by converting equation (1) to an integral equation for $\rho(\mathbf{r})$ and from this expression identifying the asymptotic term. The asymptotic term is then identified with the diffusion theory flux at large distances from boundaries and the boundary conditions satisfied by $\rho_{asy}(\mathbf{r})$ are imposed on the diffusion flux.

The boundary condition usually derived is the linear extrapolation length, or the distance at which the flux at the boundary extrapolates linearly to zero beyond the boundary. This is of course only a convenient concept and not a physical reality. The linear extrapolation length is useful since it is derived from the most convenient form of boundary conditions applicable to equation (3), the linear mixed homogeneous boundary condition



Fractional error in diffusion theory current estimate (Fig. 3)

$$\alpha\,\rho(\mathbf{r}) + \beta\frac{\partial\,\rho(\mathbf{r})}{\partial\,\mathbf{n}} = 0 \quad \text{at the boundary}$$

where $\dfrac{\partial}{\partial\,\mathbf{n}}$ indicates differentiation along the normal to the boundary surface. When this boundary condition is written in the form

$$\left[\rho(\mathbf{r}) - \lambda\frac{\partial\,\rho(\mathbf{r})}{\partial\,\mathbf{n}}\right]_{\text{boundary}} = 0 \qquad (4)$$

it defines the linear extrapolation length λ.

The effect of control surfaces of arbitrary shape may be determined (*3*), (*4*), when extrapolation lengths appropriate to simpler geometrical configurations are known. This work has been still further extended (*5*), and the effects of epithermal neutrons taken into account when dealing with heavy absorbers.

An infinite scattering and absorbing slab

We now consider the problem illustrated by Figure 1 which describes the situation to be considered in the following section. A slab, of thickness $2a$, is composed of scattering and absorbing material of mean free path l_2 and ratio of scattering to total cross-section c'. The slab is considered to be immersed in an infinite surrounding medium of scattering and absorbing material of mean free path l_1 in which uniformly distributed unit sources are present and the ratio of scattering to total cross-section is c. Using a high order approximation in the method of spherical harmonics the asymptotic flux has been determined for a number of compositions and thicknesses of plate and, by making use of equation (4), the linear extrapolation lengths have been determined. These results are presented in Figure 2 where the quantity λ/l_1 is shown against c' for different values of c and plate thickness t expressed in mean free paths of the plate material. Since the linear extrapolation length λ is based on the asymptotic flux its use might reasonably be expected to give satisfactory asymptotic flux properties but poor estimates of current. The first spherical harmonic moment may be identified with the transport current $\mathbf{j}(a)$ and thus, in the case of the infinite slab, the exact current entering a face of the slab may be determined for comparison with the diffusion theory estimate.

To arrive at a diffusion theory estimate we proceed as follows:—For the problem under consideration equation (3) takes the form

$$\nabla^2\rho - \frac{1}{L^2}\rho + \frac{1}{D} = 0 \qquad (5)$$

with the boundary conditions: ρ, finite at infinity and

$$\rho - \lambda\frac{\partial\,\rho}{\partial\,x} = 0 \quad \text{at } x = a$$

Making use of the condition at infinity gives a solution to equation (5) of the form

$$\rho\,(x) = A\,\mathrm{e}^{-x/L} + \frac{L^2}{D}$$

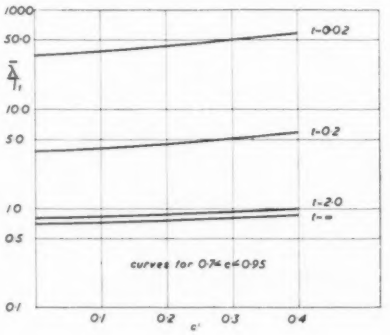
Combination of this equation and the boundary conditions at $x = a$ reduces the expression for the flux to the form

$$\rho(x) = \frac{L^2}{D}\left[1 - \frac{\exp(a-x)/L}{\left(1+\dfrac{\lambda}{L}\right)}\right]$$

Employing the diffusion theory method of calculating current quoted earlier in the introduction gives, as the net current entering the plate at $x = a$,

$$-\,\mathbf{j}(a) = \frac{L}{1+\dfrac{\lambda}{L}} \qquad (6)$$

In equation (6) the diffusion length is assumed to be calculated from the result quoted earlier and the extrapolation lengths λ are taken from the results of Figure 2. As might be expected, since the extrapolation length was based on the asymptotic flux properties, this current estimate is somewhat in error. To examine the extent of the error the results of Figure 3 are presented in which the fractional error in current is shown, taking as exact the



Variation of modified linear extrapolation length with slab and medium parameters (Fig. 4)

first spherical harmonic moment. The quantity θ plotted in Figure 3 is defined by the relationship

$$\theta = \frac{\mathbf{j}_{tr}(a) - \mathbf{j}_{diff}(a)}{\mathbf{j}_{tr}(a)}$$

where $\mathbf{j}_{tr}(a)$ is the transport theory current and $\mathbf{j}_{diff}(a)$ is the diffusion theory current estimate using the λ of Figure 2. It is clear from an inspection of the figure that reasonable results are only obtained when c is very close to unity.

It is thus desirable that a new boundary condition be found which, while giving more satisfactory current estimates than does the above method, still enables the Hurwitz-Roe technique to be used to evaluate the absorption properties of complicated geometries. The Hurwitz-Roe theory utilizes the fact that the equation taken to specify the neutron flux, our equation (3), has a very convenient mathematical form and the boundary conditions used are homogeneous. To retain their results we must then keep as our boundary condition a linear mixed homogeneous equation. A solution to the problem may be found by reinterpreting equation (6) as follows. Using the expression for L in terms of c quoted earlier, and a transport theory calculation for the net current entering a face of the slab, equation (6) may be considered as the specifying equation for a modified linear extrapolation length $\bar{\lambda}$ satisfying the boundary condition

$$\left[\rho(\mathbf{r}) - \bar{\lambda}\frac{\partial\,\rho(\mathbf{r})}{\partial\,\mathbf{n}}\right]_{\text{boundary}} = 0 \qquad (7)$$

Clearly, by virtue of its definition, this gives current estimates in the case of a slab that are exact but since the form of the original problem is unchanged the Hurwitz-Roe technique may still be applied to use the results obtained for the study of more complicated geometries.

Figure 4 shows the variation of the modified linear extrapolation length $\bar{\lambda}$ as a function of slab and surrounding medium parameters. An inspection of Figure 4 indicates a number of points of interest. Firstly, the values are now all reduced when compared with the results of Figure 2, the reduction becoming more marked as the slab thickness is reduced. Secondly, the variation with c', the ratio of scattering to total cross-section in the slab, is almost linear over the first part of the c' scale and finally, $\bar{\lambda}$ is shown as being independent of the value of c in the surrounding medium. There is in fact a slight variation but too small to illustrate on the scale used in Figure 4. If instead of the simple expression for L, the more correct transport estimate

$$\frac{1}{L\Sigma_s} = \tanh^{-1}\frac{1}{L(\Sigma_a + \Sigma_s)}$$

had been used the result would again have been similar to those of Figure 4 but $\bar{\lambda}$ would then have become markedly c dependent. In the circumstances it seems desirable to remove an extra variable if possible to simplify the results and so the elementary expression has been retained. A detailed examination of the convergence of the method of spherical harmonics for a grey slab (i.e. one in which there is absorption and no scattering) and of the extrapolation lengths applicable for flux and current estimates is to appear shortly.

References :
1. Davison, B. *Neutron Transport Theory* Oxford University Press, 1957
2. Bat, G. A. and Zaretskii, D. F. *J. Nucl. Energy* 1959, 9
3. Hurwitz, H. and Roe, G. M. *J. Nucl. Energy*, 1955, *2*, p 85
4. Stevens, H. E. *AEC Report* TID—7532 (Part 1) 1957, p 16
5. Deutsch, R. W. *Nucl. Sci and Eng.* 1959, *5* (3)
6. Jeffrey, A. *J. Nucl. Energy* (to appear) 'The convergence of the spherical harmonics method with grey plates' and 'Some properties of transport flux and current at the surface of grey plates'

Materials

The deformation of alpha uranium

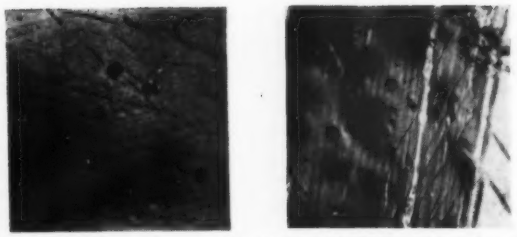
by B. R. BUTCHER, B.Sc.
Metallurgy Division, A.E.R.E., Harwell

A KNOWLEDGE of the exact crystallographic mechanisms of deformation of alpha uranium is important to theories of thermal cycling growth and of the development of preferred orientation, and to one theory at least of irradiation growth. In the studies that have been made of these mechanisms (see Table 1) one of the important facts that has emerged is that twinning plays a very minor part in deformation at high temperatures, whilst being very important at low temperatures. The temperature at which this change occurs has been given as around 350°C, and an attempt has now been made to locate it more exactly (*1*), and see if there are any obvious reasons for the change.

Small pieces of uranium of rectangular cross-section were passed slowly through the beta-alpha transformation using a steep temperature gradient. All specimens then had lengths in which the cross-section was wholly occupied by one crystal, while some had polycrystalline portions. All crystals made in this way possessed a mosaic structure. The specimens were electropolished and examined and then loaded in special grips into a testing device which was subsequently evacuated and heated to the testing temperature. A nominally tensile stress was applied and released, and after cooling the specimens were unloaded and microscopically examined. Oxide tinting of the uranium surface revealed most of the features of deformation. Slip lines showed as interruptions in the oxide layer, and the twins and crystals revealed different tints, while grain and sometimes polygon boundaries were thermally etched.

Examination of the specimens strained at 450° showed that there was very little difference in the deformation from that pertaining at room temperature. The major slip system showed as coarse wavy slip lines which could not be identified but which were attributed to pencil glide in the [100] direction (Figure 1). Fine straight slip lines were identified by a single surface method as being due to (110) slip. Line markings on one specimen were thought to be due to some form of catastrophic slip. No kink bands of the type characteristic of uranium were found, and this was tentatively ascribed to the lack of compressive stresses in the deformation test. However, something akin to a deformation band was seen as well as bent twins and continuously curved slip lines. (172) twins were definitely identified, and (130) twins were detected by a single surface method. In the single crystal portions of the specimens, the twins sometimes grew very large, and were themselves twinned (Figure 2) but in general the appearance of the twins was very similar to that at room temperature.

At 500°C, however, all the single crystal portions of the specimens deformed by slip alone, and approximately only one crystal in ten in the polycrystalline portion was heavily twinned. In one specimen, in the single crystal portion two slip systems had operated simultaneously, and these



Left: Straight and wavy slip lines (× 1300). Right: Large twin containing smaller twins and slip lines (× 500) (Figs. 1 & 2)

were provisionally put down to pencil glide in the [100] and [110] directions.

The temperature at which twinning decreases in importance in the deformation of uranium lies between 450° and 500°C, but this temperature will depend on the strain rate: fast strain rates will increase the temperature, and vice versa. Twinning, however, can never be discounted as a deformation mechanism, having been found at temperatures up to 600°C.

There may be three reasons for the disappearance of twinning: an increase in the number of slip modes, the relative decrease of the critical shear stress for slip compared to that for twinning, and the increasing possibility of grain and polygon boundary slip. The three major slip systems at 600°C, namely (001)[100], (010)[100], and (110)$<1\bar{1}0>$, also occur at room temperature, and although a fourth system has been identified at 600°C, it has such a high critical shear stress that it is unlikely that it plays an important role in the deformation. Even if the evidence presented for pencil glide in the <110> directions is accepted, this mode gives very little more freedom of slip. Thus it is very unlikely that the increase in slip modes could account for the disappearance of twinning.

On the other hand (001)[100] slip, which occurs only as cross slip at room temperature, is the major slip mode at 600°C, with a very small critical shear stress, so the relative reduction of critical shear stress could play a large role in the disappearance of twinning.

Reference

1. Butcher, B. R. *A.E.R.E. Report* No. 2898

TABLE 1

INVESTIGATOR AND METHOD	TWIN PLANES LISTED IN ORDER OF IMPORTANCE	SLIP SYSTEMS LISTED IN ORDER OF IMPORTANCE	CROSS SLIP SYSTEMS	KINK PLANES
Cahn. Room temperature deformation and thermal twinning of polycrystalline material	(130) ~(172) (112) (121)*	(010) [100] (110)< ? >	(011) [100] (013) [100] (001) [100] (023) [100]*	Approx. ⊥ [100]
Lloyd and Chiswick. Room temperature compression of 'perfect' single crystals	(130) ~(172) ~(176)	(010) [100] (011)< ? >	(001) [100]	Approx. ⊥ [100]
Chiswick et al. Compression of 'perfect' single crystals at 600°C	(130)~(172)	(001) [100] (010) [100] (110)<1$\bar{1}$0> (021)<1$\bar{1}$2>		

*Not well ubstantiated

Instrumentation

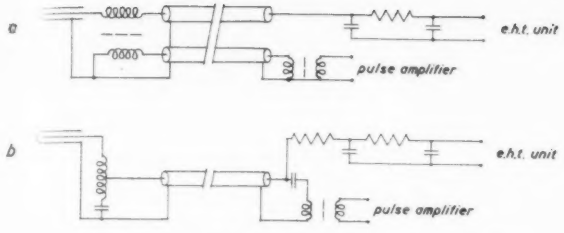
Pulse transformers for counting

by A. L. GRAY, B.Sc. *and* R. WEBSTER, B.Sc., *Plessey Nucleonics Ltd.*

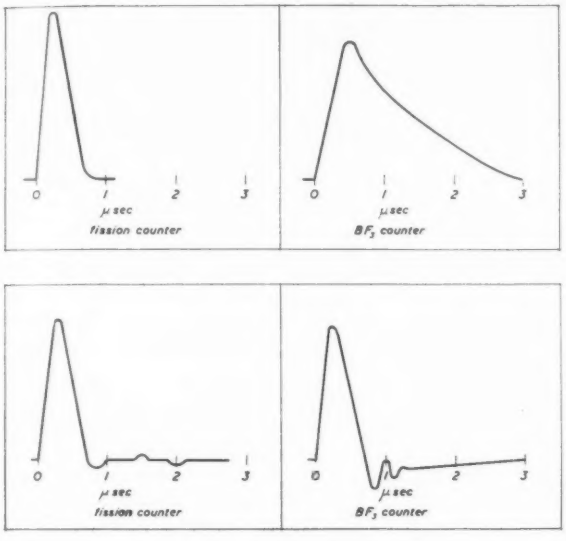
THE USE of neutron sensitive pulse counters in reactor control instrumentation is often complicated by the necessity to locate them in positions which are some considerable distance from the pulse amplifier. It is common practice to use solid polythene insulated coaxial cable between the counter and amplifier so that the capacitance between core and sheath of this cable appears in parallel with the counter and amplifier input circuit capacitances. Typical counter capacitances are 100pf for a fission counter and 20pf for a BF_3 proportional counter while the capacitance of most suitable cables is of the order of 20pf per foot. The effect of a long length of cable on the counter performance is thus to reduce the voltage amplitude of the charge pulse at the amplifier input grid. In practice capacitances of up to 500pf are usable with most fission counters before the pulse height corresponding to the upper end of the bias plateau is lost in the noise level of a good pulse amplifier, and this limits cable lengths to some 20 ft. In the case of BF_3 proportional counters where long cables are necessary the pulse height may be increased by operation at higher gas multiplication factors but this has the effect of shortening the counter life which is undesirable for reactor use, although it may well be acceptable in experimental work. For example, a 12EB40 counter may be usefully operated with up to 25 ft of cable at an E.H.T. of 1·8 kV (M = 40) and up to 200 ft at 2·4 kV (M = 900). On cable lengths above about 100 ft however, difficulty may be experienced with interference from reflections at the ends of the cable unless the cable is terminated in its characteristic impedance, which, however, reduces the pulse height again.

In order to minimize these difficulties the input stages of the pulse amplifier are usually separately mounted as a head amplifier unit which may be located near the counter and in many cases this is completely satisfactory. Where space is at a premium special head amplifiers have been used which may be mounted directly on the end of the counter. These however are relatively complex and require cooling at temperatures above 70°C, and in addition, offer the normal maintenance problems associated with the use of valve amplifiers.

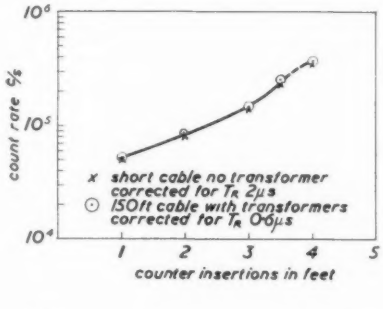
A logical approach to this problem is to use the coaxial cable as a transmission line, as is normally the case between head and main amplifier, when the loss of pulse height in the line is less than 1 db per 100 ft, and to use pulse transformers to provide the impedance match at either end of the line. The d.c. path for the E.H.T. supply may then be provided either by separate cable or down



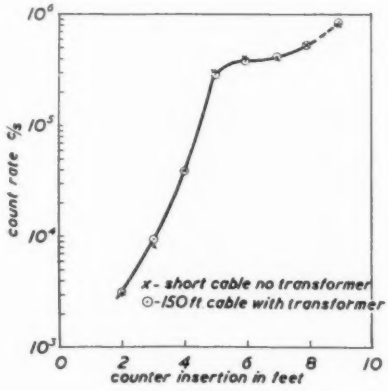
Circuit of matching transformer connexions (Fig. 1)



Output pulse shapes from BF_3 and fission counters; above: on short cable, below: with 150 ft of cable using matched transformers (Fig. 2)


count rate %
x short cable no transformer corrected for TR 2μs
⊙ 150ft cable with transformers corrected for TR 0·6μs
counter insertions in feet

Flux plot with BF_3 counter, sensitivity approx. 3 c/n (Fig. 3)



Flux plot with fission counter, sensitivity approx. 0·2 c/n, corrected for T_R = 0·6 μs in both cases (Fig. 4)

the same line using a blocking capacitor at the counter (Figure 1).

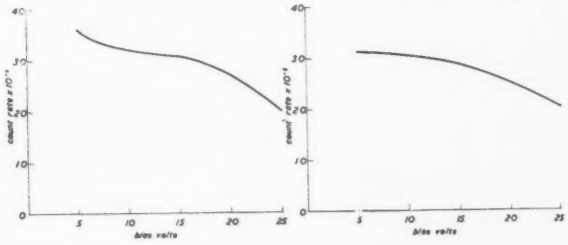
A pulse transformer system for use with fission counters and BF_3 proportional counters has recently been developed by Plessey Nucleonics Ltd. which permits operation over cable lengths of several hundred feet without loss of resolution. The transformers use high frequency ferrite cores in the normal 25 mm pot core mounting. The system of E.H.T. supply preferred is that shown in Figure 1a using a second cable, as this avoids the bulk of the capacitor at the counter.

The performance of fission counters and BF_3 proportional counters using these transformers are virtually independent of cable length. The shape of the pulses obtained at the output of a normal pulse amplifier type 1515A is shown in Figure 2 for both BF_3 and fission counters for a short length of cable between counter and head amplifier and for a length of 150 ft matched with appropriate pulse transformers. For the BF_3 counter time constants of $T_1 = T_2 = 0{\cdot}32\ \mu s$ were used, giving, without the transformer, a resolving time of approximately 2 μs at the discriminator level used. The effective time constant of the transformer system however is shorter than 0·32 μs and the effect of this is to improve the overall resolution to approximately 0·6 μs. The negative overshoot with the BF_3 counter is sufficiently small to have negligible effect on pulse amplitude at spacings of more than 0·5 μs and very little ringing is apparent. The overshoot is completely terminated within 3 μs of the leading edge. The pulse shape remains unchanged except for a loss of amplitude of about 2 db in a run of 750 ft of UR39 cable.

In the case of the fission counter (Plessey Nucleonics Type PNI 1049) the time constants of the amplifier were set to $T_1 = T_2 = 0{\cdot}08\ \mu s$ and the effect of the transformer time constant is not apparent, the pulse shapes with and without the transformer being practically identical. The negative overshoot is relatively much smaller than with the BF_3 counter and the overall resolving time of the system is unchanged. Again the only effect of increasing the cable length between transformers is to introduce attenuation at the rate of about 1 db per 400 ft.

The operation of both types of counter at high count rates over 150 ft of cable using matching transformers is shown in Figures 3 and 4 in comparison with the direct results on a short cable. These represent flux plots in a reactor experimental hole and for the fission chamber the results with the long cable fall exactly on the short cable plots up to 6×10^5 c/s. (Corrections are made in both cases for counting loss using a resolving time of 0·6 μs.) In the case of the BF_3 counter the inferior resolution of the counter on a short cable with time constants of 0·32 μs results in a high counting loss above 10^5 c/s but correction for this, assuming a resolving time of 2 μs, gives good agreement in spite of the excessive counting loss, with the values plotted for the transformer using a resolving time of 0·6 μs. The plateaux obtained at a count rate of 3×10^5 c/s using the transformers and 150 ft of line are shown in Figure 5.

Discriminator bias curves using matching transformers with 150 ft of cable; left, fission, and right, BF_3 counters (Fig. 5)



Looking through the conveyor line

Now in production, the AEC's new pilot plant is probably the most advanced of its kind in the world

Plutonium production at Argonne

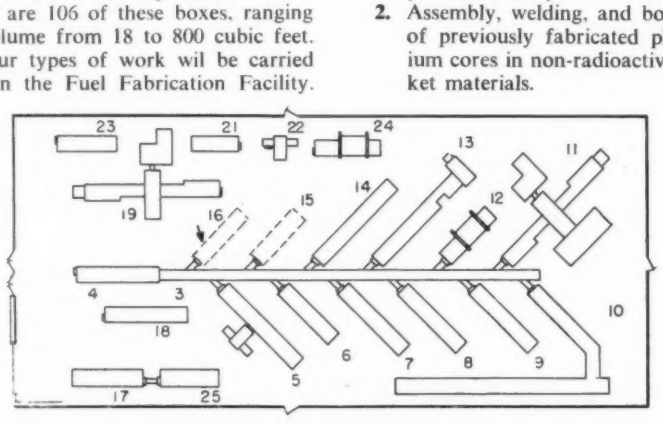
THE FUEL Fabrication Facility at the Argonne National Laboratory has been provided to fill the need for a fabrication process development laboratory, a pilot plant, and a facility for the limited production of plutonium fuel elements.

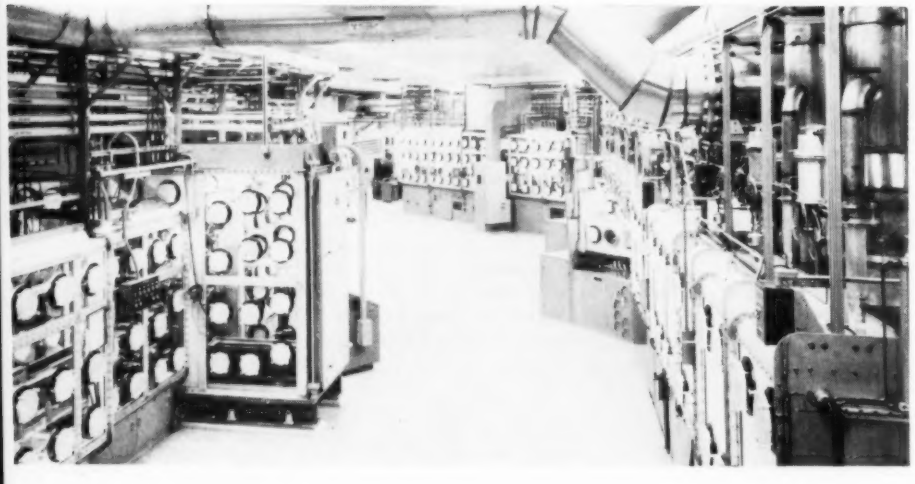
Reactor research at Argonne demands constantly changing core designs. Each reactor is basically a " test bed " for different types of fuel elements so that a standard fuel line is impracticable. Hence, flexibility is an important feature of the facility.

To protect operating personnel, several methods of providing safety against alpha particle contamination were studied. That finally adopted is an integrated system of glove boxes branching out in a herringbone pattern. Gasketed together to prevent air leakage, these may be used with either air or a helium atmosphere, depending on the materials or operations. In all, there are 106 of these boxes, ranging in volume from 18 to 800 cubic feet.

Four types of work wil be carried out in the Fuel Fabrication Facility. These are:

1. Fabrication of, or work directly upon, reactor fuels containing plutonium alloys.
2. Assembly, welding, and bonding of previously fabricated plutonium cores in non-radioactive jacket materials.





Process line above shows: 3. Conveyor, 4. Introduction and removal, 5. Machine shop, 6. Electrolysis and aqueous solution, 7. Weighing and inspection, 8. Centrifugal casting, 9. Ingot casting, 10. Extrusion press, 11. Rolling mill 'A', 12. Plate shear, 13. Wire fabrication, 14. Press work, 15. Future line, 16. Future line, 17. Welding and cladding, 18. Decontamination, 19. Rolling mill 'B', 21. Work bench, 22. Milling machine, 23. Lathe, 24. Plate shear, 25. Liquid metal filling

Overhead view of the fuel fabrication area (left) shows in the left foreground the rolling mill with the conveyor line on the right. Stainless steel tube connecting the two sections is normal exhaust ductwork

3. Metal working, machining, cutting, or heat treating operations upon the jacketed pieces.

A specialized line (4) using a system of locks is used to introduce into or remove non-radioactive or packaged materials from the system. Contaminated materials are removed from the hood system by the plastic pouch transfer technique.

The operating glove box lines are interconnected by means of a 102 ft long hooded conveyor (3). This consists of two rails upon which a dolly is drawn by a continuous roller chain. Transfer from the conveyor line to the operating hood lines (5 to 14 inclusive), is made on two-way ball-bearing slide platforms. These may be projected into either the conveyor or into the operating line. Each operating line is separated from the conveyor by means of a gas-tight, pneumatically operated sealing door. The transitions and operating hood lines were laid out with their longitudinal axis at 135° from the axis of the conveyor line allowing the transfer of pieces 6 to 8 feet long into a conveyor enclosure only 30 inches wide.

Another overhead view of the fuel fabrication area shows from right to left: two casting lines, weighing and inspecting line, machine shop line and liquid metal line. Far right is one end of the conveyor line

Contamination risk equipment

The glove boxes are themselves supported upon housings for contamination risk equipment, such as vacuum pumping systems and hydraulic systems. This equipment will not normally be radioactive but may become contaminated through failure of gaskets or seals.

A water cooling system within the boxes will be operated at negative pressure with respect to hood atmosphere. Provision is made for an inert helium atmosphere in all lines connected to the conveyor line except the aqueous solution and electrolysis line (6).

The operations of jacketing, welding, and liquid metal bonding will be done in lines 17 and 25. These lines are also equipped for helium atmosphere operation. Every effort will be made to keep the inside of lines 17 and 25 at a low level of contamination so that finished pieces of radioactive fuel may be assembled and welded into uncontaminated jackets in these boxes. 17 and 25 are not connected to the highly radioactive central conveyorized system. In spite of all efforts to keep the jackets clean, some contamination will from time to time be picked up on the fuel specimens that are to be jacketed. Glovebox line 18 has been provided with equipment for decontamination of these jacketed specimens.

Lines 19, 21, 22, 23, and 24, at the north side of the conveyorized system, are used for further fabrication, machining, and assembly operations upon jacketed specimens. These will be kept uncontaminated.

The glove boxes developed for this job use aluminium alloy extrusions and corner castings. Gasket grooves, ventilation ducts, and the required structural shapes were formed by the extrusion process to minimize machining requirements. Heavy aluminium floor plates were used for most of the hoods although upon occasion steel plate floors were substituted.

The windows are of cast allyl plastic providing better optical properties, greater resistance to solvents and corrosive substances, and a much higher degree of hardness and scratch resistance than methacrylate.

Circulation of helium

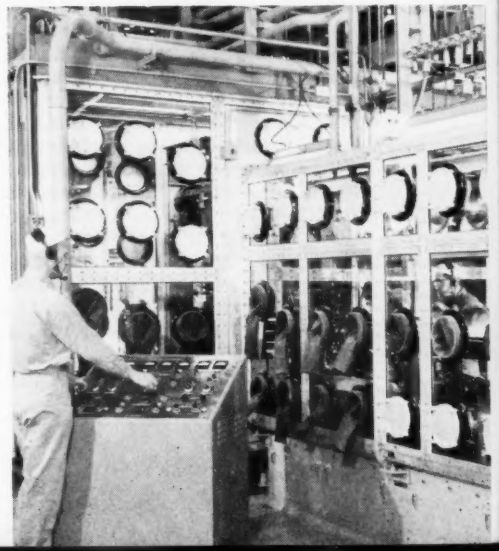
The helium system consists of two circuits (a) a recirculating circuit, handling either 1000 or 2000 ft^3/min, and (b) a regenerative purifying circuit handling approximately 100 ft^3/min. The helium is pumped at less than atmospheric pressure and leakage of air into the system is estimated to be 0·02% of the gas in the system per hour. The regenerative purifying circuit was designed to remove 8 to 10 times this amount. Loss of helium due to objects being introduced or removed is estimated at between 200 and 400 cubic feet per week of operation.

The recirculating helium blowers are seven-stage turbo-compressors which, at 3500 rev/min, handle approximately 1000 ft^3/min at about $\frac{1}{2}$ lb/in^2.

In the repurifying circuit, a two-stage sealed compressor raises the pressure to 165 lb/$in.^2$ Both intercooling and aftercooling are employed. The cooled helium is then passed through drying towers where almost all moisture is removed. After passing through the drying towers, the gas is piped to a cold exchanger where it is cooled to -40°F by evaporation of freon gas. The helium is then passed through four activated carbon towers in series.

Provision has been made to cool the gas from the carbon towers to liquid nitrogen temperatures and to pass it countercurrently through gas-to-gas heat exchangers located between the carbon towers. This provides the necessary low temperatures required for start-up operations with impure gas. Regeneration of the activated carbon towers is accomplished by valving the main flow of helium to an alternate set of carbon towers and then evacuating the original towers, thereby clearing them of oxygen. Provision is made to pipe a small flow of hot helium to the towers from the compressor when hot regeneration or defrosting is required.

This rolling mill is operated from two remote control stations, one just visible on the right through the glove boxes



Irradiation services at Wantage

Prototype commercial plant nears completion

BY EARLY 1958, the work of the Isotope Division of AERE, Harwell, on the use of intense radiation for industrial purposes had reached the stage where a pilot commercial plant was required. The Technological Irradiation Group of the Isotope Division, in collaboration with the Engineering Division at Harwell, drew up the basic design requirements for the continuous irradiation of packages, 14 in. × 9 in. × 12 in. high, weighing anything between 5 and 40 lb each. The total flow would be infinitely variable between 234 and 28,080 packages per twenty-four hours which would enable the irradiation time to be varied from a minimum of 6 minutes to a maximum of 40 hours. Continuous operation was specified so that the maximum utilization of the source would be achieved and the plant worked as an economical proposition. After further consideration, it was decided to make the packages 1 cu. ft in size.

The projected plant was seen as incorporating a large cobalt-60 source, heavily shielded, with the material to be irradiated passing round it in a continuous stream. Essential requirements were five-fold: automatic movement of the material within the cell; immediate stoppage of radiation in the event of a failure in the transmission of the packages in the vicinity of the source; commercial feasibility; possibility of using similar plant industrially, employing comparatively unskilled operators; impossibility of entry into the active area unless the source had been previously dumped in its storage pond. The form the installation took was that of a continuous conveyor belt passing into and out of the irradiation cell, the speed of which could be varied to suit the particular material to be processed, with all operating and safety arrangements relying on the continuous functioning of the conveyor system, automatically failing 'safe'. Due to the very wide range of possible applications of such an irradiation process, twin production lines or conveyor systems were proposed.

In June 1958, the design had been advanced far enough to call industry in to work on the detailed mechanical designs outside the irradiating cell. It was arranged that this should be carried out by the Rubery Owen Organization. Parallel with this work, the Atomic Energy Authority proceeded with the design of the source, its handling equipment and interlocking door mechanism. To meet the overall requirements, it was decided that the two input and two output conveyors would have to be capable of dealing with the standard packages as follows:—

	INNER CONVEYOR	OUTER CONVEYOR
Stay-in time	20 min–40 h	6 min–12 h
Time to handle one package	13½ sec–26½ min	4 sec–8 min
Daily flow	6480–54	21,600–180

It was specified that these conveyors should feed and take away the packages from the irradiating cell so that, while they were exposed to the source, they would be packed two-deep on either side of the source and touching one another as they moved along each of the horizontal levels in the cell. As there is only 1 in. clearance vertically between each horizontal level, when loaded, the packages virtually form a solid wall and so obtain the maximum utilization of the source.

Diversified resources

The source installation was designed by the Engineering Division of the AERE and includes a shielded water pond source storage complete with loading jig, elevating gear and plug door, with interlocking gear, into the radiation cell. For the irradiation process, the source is elevated and positioned within a shuffling machine which moves the packages through two banks of five horizontal levels, at a rate of one package space per operation. This machine was basically designed at Harwell and subsequently the Rubery Owen Organization carried out limited detail designing.

The overall design work assigned to industry was centred at Darlaston and broken down into three sections amongst the Owen organization: overall control mechanisms, hydraulic drive units and pumping sets for the transfer jacks by Electro-Hydraulics, at Warrington; conveyors and storage rack by Rubery Owen's Research and Development Group, at Darlaston; and structural work by Salopian Engineers Ltd, of Press.

A working proposition

The finalized design was in the form of two input storage units, two input 'Paternoster' elevator conveyors, an irradiation unit, shuffling machine for the controlled passage of packages around the source, two output 'Paternoster' elevators and a large output storage.

The two input storage racks each have four shelves and each shelf can accommodate 368 packages, which are hand loaded onto the shelves. The racks are hydraulically operated so that each line of packages, supported the full length of their backs by a frame, are brought into position for loading onto the conveyor at the correct time. This is effected by a series of microswitches, and preselection of the order in which each shelf is emptied can be made on a control unit provided for each storage rack. Under maximum loading conditions, the total weight of the packages will be nearly 7 tons and to transfer these to the conveyor, when operating on a two-second cycle, a driving torque of 6760 lb/in. is necessary.

The two input 'Paternoster' elevators, forming the inner and outer conveyors, are designed around spacing the packages at 2 ft centres. On this basis, the accuracy of the infinitely variable speed hydraulic motors, used for driving the conveyors, is set; because of the wide variation in output

required, it has been necessary to interpose a two-speed fixed ratio gear box in each drive. The specified design accuracy of the motors has been established at ± 1% of the irradiation time period and aims at achieving an overall running efficiency of 5% on the time period.

As the speed of the conveyor is used as the key time measure, this is controlled from an electronic clock which triggers off all other motions. Through two cams on each conveyor, using displacement servos acting vertically and horizontally, warning of changes in either loading, transfer of missing packages are indicated. This warning in turn automatically operates an interlock fitted on each conveyor, as part of the safety arrangements. By this means it is ensured that the irradiation source is dumped immediately into the storage pond when circulation of the packages is stopped. Subsequent start-up is so arranged that the re-introduction of the source is brought about when the conveyor resumes its travel, so that the packages within the cell, during any 'failure' time, will still only receive the correct dosage.

Handling the source

The irradiation source of cobalt-60, in rectangular form, initially will be 150,000 curies which will provide a throughput of 7 megarad tons per day, although the shielding has been designed for sources of up to 500,000 curies.

The source is raised and lowered from and into the storage pond by a hydraulic mechanism; the control valve for which is located outside the cell and is adjacent to the main control console. This hydraulic circuit incorporates an interlock whereby it is impossible to remove the plug door until the source is fully submerged in its pond.

Around the source, when it is in its working position, is the irradiation machine which by means of a shuffling action, passes both lines of packages from the input conveyors along five horizontal levels in a zig-zag pattern. It then transfers them across to the other face of the source and the zig-zag movement is repeated through a further five horizontal levels. All these movements are effected through hydraulic mechanisms which work on the basis of one package length per each cycle. The pattern of the path taken by each package is such that every package receives exactly the same amount of irradiation and that it is almost equally applied to the whole contents of the package.

On leaving the irradiation machine, the packages are passed through the shielding wall on two output 'Paternoster' conveyors to two sets of post-treatment storage racks where they are left until ready for despatch.

The control console, located on the outer wall of the shielding and to the left of the plug door, centralizes all controls and service indicators, which include speed of conveyors, position of source, storage pond water level, cell air extraction system, demineralized water circulation, CO_2 discharge system for fire prevention, position of the safety gate and plug door.

Erection well advanced

This plant, under construction at the Authority's establishment at Wantage, is now nearing completion and expected to commence operating towards the end of November. The entire facility occupies an area of approximately 10,000 sq.ft, with the irradiation cell itself occupying roughly 1000 sq.ft. The massive concrete shielding was carried out under the supervision of AEA Risley and is so shaped that irradiation effects cannot escape through the conveyor ports. All the hydraulic jacks, control mechanisms and piping were supplied by Electro-Hydraulics, who used Vickers VSG hydraulic units to provide the variable speeds required for the input conveyors —20 h.p. for the outer and 7½ h.p. for the inner unit.

The control panel is built around a Venner Electronics timing unit giving the base time periods and Muirhead speed indicators show the conveyors' speeds. The installation of all the mechanical and hydraulic equipment, apart from the irradiation machine but including its hydraulic pipework, is being carried out by the Rubery Owen Organization.

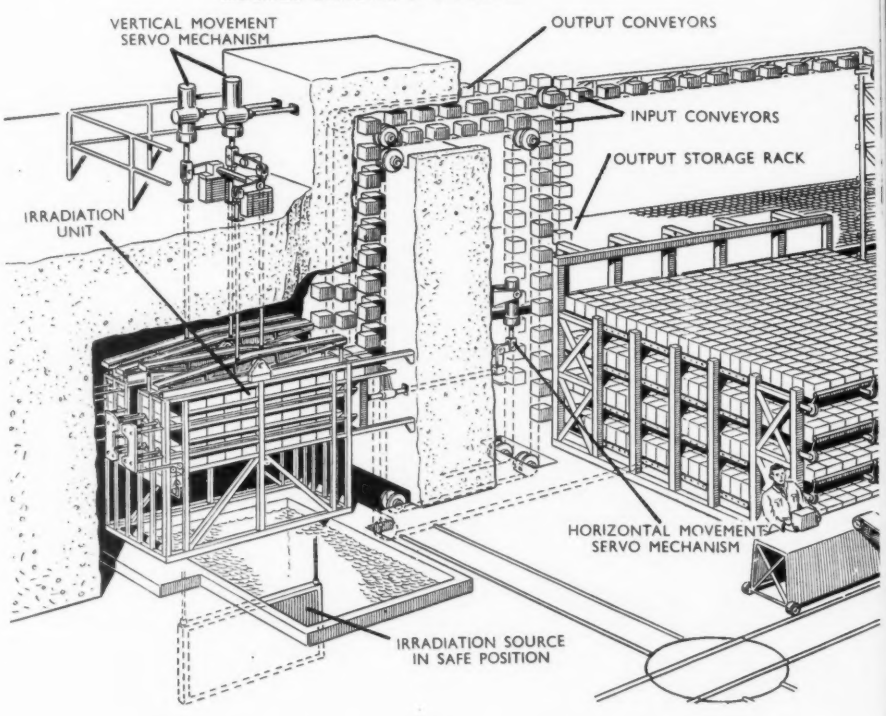
Guiding industry

The work for which this installation will be used, will be mainly directed towards the irradiation of polyethylene components to bring about cross-linking; the sterilization of medical products, predominantly catheters, syringes and dressings; and relatively small quantities of experimental materials.

When being employed for sterilizing purposes and a dose of the order of 2½ rads is given, the plant is capable of rendering some three tons of such materials completely sterile in 24 hours.

Earlier work in this field employed the spent fuel elements of the Materials Testing Reactor, Pluto, which, while successful, proved costly in terms of handling and man-hours. The new installation will act as a model for the industrial application of irradiation techniques utilizing cobalt sources which are expected to become cheaper as large quantities of initial radioactive material become available when the nuclear power programme has been in progress for some years.

CONTINUOUS IRRADIATION. The complete operating mechanisms are hydraulically powered and electronically controlled to give uniform treatment with the maximum utilization of the source



Cross Section by GRACCHUS

SOME of the staff on the British nuclear stand at the Milan Fair last April were observed quietly grinding their teeth at the number of people who flowed gently past the stand and stopped at the next one; this featured a 'nuclear vaporization system' for preserving fruit, vegetables and meat almost indefinitely. Sponsored by Dr. Anna Maria Dei, a smart blonde female scientist in her fifties, it attracted considerable attention from passing scientists, as well as industrialists and farmers. No one was very clear on how the system worked but it looked most impressive in its results. During the past few months Dr. Dei had opened offices in several towns in Northern Italy, exhibited in several trade shows and was pictured in Italian papers more than once talking to visiting dignitaries. According to the official publication of the Padua Fair, which ran an article on her, Italy had 'achieved an important supremacy' and got ahead of America and the UK in a most important field.

Alas! It now appears that the whole thing may have been a fraud on a splendid scale. The *Daily Telegraph* reported recently that Dr. Dei has been arrested in Como and is to be charged with extracting some thousands of pounds from businessmen who rushed to get her to sign contracts to preserve their tinned meats, cheeses and butter. The report says the name Dr. Dei was assumed and that her real name is Neera Tommasini; even the blonde hair was a wig. If proved, the case will be Italy's first big nuclear swindle. I suppose, as a now established industry, atomic energy must offer its fair share of opportunities to the wide boys (and girls).

THOUGH not as immediately startling as 'atomic vaporizers' some recent work by a member of US Lockheed's nuclear and space division, Dr. Frederick Alzofon, may have some far-reaching results. In a paper presented to the American Astronautical Society he expounds a new concept of gravity, in which he suggests that it is 'the result of forces generated on a sub-atomic level' — the radiation of rapidly fluctuating energy by the particles. 'Only if we understand the physical processes giving rise to gravitational fields can we hope to control it,' he says. The gravitational field is proportional to the mass of the body producing it and since all of the mass of any object is concentrated in atomic nuclei and electrons, it is suggested that processes characterizing these are responsible for the field. These forces generated on a sub-atomic level are characterized by rapid fluctuations of radiated energy and can be identified with the creation and annihilation of matter.

It is a more readily understandable explanation, he maintains, than the orthodox one, and therefore, if correct, 'could lead to a more thorough and useful understanding of gravitational fields and some possible practical applications in being able to control it.' The idea of controlling gravity is interesting enough to most engineers; to those concerned with rockets it is sheer delight: at the moment it takes about one hundred pounds of booster to get one pound of payload into orbit. The theory gives plenty of food for thought to the physicists too. Dealing with the effect of his theories on current ideas about the nature of the universe, Dr. Alzofon said they might show that it is in equilibrium, and not expanding as so many authorities believe. The theory offers, for example, a new explanation for the red shift; it may simply be due to the evaporation of energy from the light of the star instead of to the recession of the star in question.

I FOUND the recent report from the Select Committee on Estimates on the AEA industrial groups a mine of interesting information. Anyone who wants an amusing hour or two should go through it and compare the detailed answers extracted by the Committee from Authority witnesses on any one topic with the pap presented in the Annual report. Especially illuminating were the sections concerned with Authority efforts to recover some of its money. The sale of fuel elements, which netted something under £1 million in 1958-9, is expected to go up to about £10 million in the following year and £17 million in the year after that. How about the long-term prospects? An Authority witness stated that sales 'could well reach figures of the order of £30 to £40 million in five or six years time.' What with this and other sales, the £2·5 million royalties to be charged for each power station based on its R & D., the issue of licences under patents, and the sale of information and consultant's fees the AEA hopes to get quite a lot of its money back. The only snag is that these extras make it more difficult for the consortia to sell reactors overseas —so difficult in fact that its high time we had a fresh look at the whole system.

When a year or two ago the consortia pointed despairingly at the generous credit terms and absence of royalties in US commercial offers the Government blandly replied that our reactors could stand on their own feet and get themselves sold without inducements on never never lines. Well, the Government was unduly optimistic, but it still shows no sign of altering its policy on credit. As far as patents and royalties are concerned, British Government practice, unlike American, has always been to make charges for the commercial exploitation of developments made possible by spending public money. It may well be time to change this policy. In the meantime one sympathizes with the consortia in their efforts to get royalties down as far as they can and is not surprised that many firms consider the terms asked for licence agreements prohibitive.

While the Authority is trying to make its accounts look better by obtaining more revenue, it is itself having to pay much higher prices for its uranium than it would like. The difference between the price to the AEA under contracts signed years ago when everyone was concerned about securing their supplies and the current market price is reaching ridiculous levels. A reasonable price for ore could cut generating costs by as much as 10% and efforts to negotiate better contracts must be kept up. So far only the South African producers have proved flexible.

On record

As for the peacetime uses of atomic energy, all that we have are promises, which in recent months have become increasingly tentative, that at some unidentified future moment electricity will thus be generated at a cost as low as the present cost of producing electricity by burning oil or coal under boilers. — Prof. John Jewkes, Oxford University.

New Product Survey

PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

LARGE SOURCES

caged Krypton-85

Giving greater safety, large sources of radioactive materials suitable for many new industrial and laboratory applications are now available through a new Tracerlab chemical manufacturing process. By crystallizing hydroquinone in the presence of gaseous krypton-85 so that as the crystals form, atoms of the gas become trapped within the interlocking network of molecules. The resulting material is called a Clathrate and contains the krypton in approximately one thirtieth of its normal volume. The crystal structure does not interfere with the radiation emitted but acts as effectively as a thick walled pressure cylinder in restraining the krypton gas.

The makers say that an important safety factor inherent in this form of manufacture is that, should a clathrate material be spilled, decontamination can be accomplished by pouring water or ketone solvent over the affected area. This dissolves the crystals, causing release of the krypton gas which is rapidly diluted and carried away in the atmosphere.

Tick **No 208** on reply card

SHIELDING BRICKS

pressure moulding

At the instigation of and in cooperation with the AERE, Harwell, British Lead Mills Ltd., BLM, have developed a pressure moulding technique for the production of personnel shielding bricks and this method ensures that these have a greater density and freedom from porosity. BLM are producing these bricks in 2 in. and 4 in. thicknesses in the form of standard, corner, top, bottom, half and quarter, which can be built into a complete surround to give the maximum thickness at any point of 2 in. or 4 in. or multiples thereof. All joining surfaces are shaped with either a male or female form to provide secure interlocking. AERE have awarded a two-year contract to BLM for the supply of these pressure moulded lead bricks.

Tick **No 209** on reply card

THERMAL SIMULATOR

all types of reactors

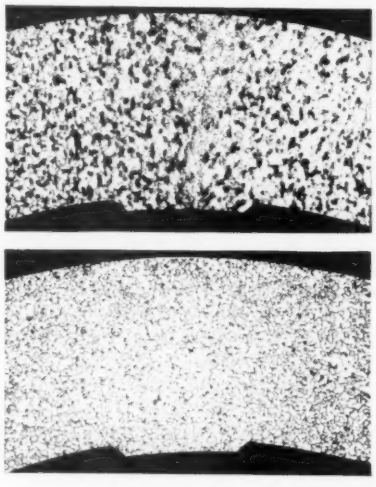
A complete instrumented unit which realistically reproduces the controls of a nuclear power station has been developed by the American associates of Honeywell Controls Ltd. Known as a thermal plant simulator it can be adopted, in conjunction with a reactor simulator, to give the operating conditions of any complete nuclear installation. It enables the training of nuclear engineering personnel to be carried out economically and safely. While these instruments were originally designed as training devices for use by colleges and universities, they can be used independently for studies and experiments in nuclear design and to solve operational problems encountered in nuclear power plants.

Tick **No 210** on reply card

LECTROSONIC

welded tubing

Following five years of extensive field tests, The Babcock & Wilcox Company of America have made their Lectrosonic welded steel tubing available. This material designed specifically for use in heat exchangers has proved equal to or superior to seamless carbon steel tubing for this duty. The high standard necessary is achieved by integrating a quality control system in the fabrication process. This tubing is proving to be economical in use and shows savings ranging from 10 to 32 per cent. over the grades of seamless tubing it has been designed to replace.



The grain structure of Lectrosonic tubing is modified during manufacture—the top photomicrograph is the 'as welded' state and below is the same joint after annealing. The weld area is raised for identification only

Tick **No 211** on reply card

CONSTANT SUPPORT HANGERS

improved Genspring models

For many years, the type H12 Genspring met the requirement of power stations, petroleum refineries and chemical processing. It had a max. load of 7300 lb and a max. vertical travel of 4 in. Further increases in thermal movement due to higher steam temperatures and pressures resulted in the design of the 'W' Genspring. The travel range was extended to 12 in. with 8400 lb load, but with a reduced vertical travel to 3·381 in., the load could be increased to 30,000 lb. Such types were supplied to Calder A, Calder B, and Chapelcross and are now being supplied to Bradwell, Berkeley and Hunterston nuclear power stations.

During 1958 Vokes Genspring developed a new range that offers increased efficiency at less cost. Models M1 to M4 cover load ranges of 3500 to 22,000 lb over vertical movements up to 12 in. With still further requirements for supports capable of meeting increasing heavy load, the 'M' range was extended to include two more models, the M5 and M6.

The M5 can support 45,000 lb over a vertical movement of 4 inches and the M6 can support 90,000 lb over the same movement. Also available is the MU model with the same loading and travel ranges, but adapted to support below the pipe or ducting.

Testing the constant support hanger calls for extreme accuracy over a wide range of loading. Vokes have designed and constructed several test rigs and the latest heavy reinforced steel structure can accommodate the load requirements for testing the M5 and M6 supports.

Tick **No 212** on reply card

ELECTRONIC COUNTERS

building up systems

Two new types of counting units, designed to enable industrial electronic control systems to be built up, have been introduced by Mullard Equipment Ltd. The pre-set counter, Type 89930, provides a single decade of counting at speeds up to 2000 per second and can be programmed to issue up to ten command signals to the controlled machine once specified values have been reached. The unit may be operated from any normal type of input transducer, such as phototransistors or limit switches, and a transistorized pulse-forming unit is available to convert the output from such devices into a pulse of suitable shape to operate the trigger tubes.

The decade counting unit, Type 89929, is intended for making up general purpose equipment where the counter is not required to produce command signals. It is capable of counting speeds of up to 30,000 a second and special add-on units are available to increase the speed up to 100,000 counts per second. A number of other plug-on ancillary units are available and include a pulse-former, a gating unit which can also be used as a pulse preamplifier to increase the sensitivity of the counter, a timing unit and

an electro-mechanical counting unit, which, for low speed counting, can be used in place of the last decade unit in a chain to increase the counting capacity by a factor of 1000.

Tick **No 213** on reply card

POWER SUPPLY
for ionization chambers

A new model of Hamner Electronics N-413 regulated high voltage power supply provides 100 to 5000 volts d.c. continuously. Its 10 mA capacity enables it to furnish power to several photomultiplier tubes simultaneously for coincidence studies in scintillation counting and ionization chambers work. It is standard cell referenced and noise and ripple is less than 50 mV peak to peak.

The N-413 uses a unique principle to achieve high voltage with reversible

Continuous regulated high voltage power supply between 100 and 5000 volts is provided by Hamner's N-413 unit for use with several photomultiplier tubes

polarity. The high voltage transformer is driven by a push-pull power amplifier, stabilized to maintain symmetry, while the output is rectified by means of a high voltage bridge rectifier and polarity is determined by a polarity reversing switch on the front panel. The feedback voltage amplifier loops and chassis are at ground potential.

Tick **No 214** on reply card

ROTARY VACUUM PUMPS
in nuclear power stations

Rotary vane exhausters, made by the B. A. Holland Engineering Company, will be incorporated in the condensing plant at Berkeley nuclear power station A special feature of the Holland/SLM pumps is that the blades are restrained from actually touching the casing bore by two floating rings. These are fitted near each end of the rotor and have a bore which is very slightly less than the casing bore. Thus as the rotor turns, these floating rings are carried round with the blades and keep the friction of the blade edges against the casing wall to a minimum.

When the rotor revolves, the blades, housed in slots in the rotor, are thrown outwards to subdivide the crescent shape of the casing into compartments. The capacity of these compartments varies between a minimum and a maximum volume so forming an evacuation and exhaust cycle. Running at speed, this cycle is continuous and gives an even flow without any pulsating.

The model V.280 units being installed at Berkeley have a suction capacity of 1120 cu ft of free air per minute at 95% vacuum and absorb 46 bhp when running at their operating speed of 485 rev/min.

Tick **No 215** on reply card

SCINTILLATION DETECTOR
integral preamplifier

The scintillation detector, Model DS-12, will drive up to 500 ft of cable without an auxiliary preamplifier or power source, for use with radiation measurement instruments. This unit, made by Technical Measurement Corporation, provides an integral transistor preamplifier circuit which operates on a small part of the voltage supplied to the photomultiplier. By making use of only a single source voltage, it may be used with counting instruments that are not equipped for the connection of accessories and the DS-12 with the additional circuitry, is no larger than standard scintillation detectors. The rise time is 0·15μs, extremely linear pulses up to 1 volt in height are provided and an internal clipping circuit sets the output pulse duration at 1μs. The makers supply interchangeable alpha, beta and gamma detector crystals for use with this detector.

Tick **No 216** on reply card

MASTER GAUGING BALLS
easing inspection

Used in the United States for some time, master gauging balls are now available in the UK through Insley Industrial Supply Co. These precision balls are available in sizes from 3/64 in. to 1 in. diameter, in 1/64 in. increments and are suitable for setting comparators and other types of toolroom gauging equipment or for use as inspection department standards.

The chrome alloy steel balls are hardened to 63-65 Rockwell C and made so that tolerances are held $\pm$ 0·00001 in. on diameter and 0·00001 in. on sphericity, with a surface finish of 1 micro-inch. These gauges are available either singly or in sets, packed in a wooden case complete with tweezers for handling.

A parallel set of tooling balls are available in a similar range of standard sizes. These are precision spheres with an internal shank. Made from stainless steel hardened to 55-58 Rockwell C and held to a tolerance of $\pm$ 0·0001 in. on diameter and 0·0002 in. concentricity, these are intended for use as reference points in the manufacture, inspection and set-up of jigs, tools and fixtures.

Tick **No 217** on reply card

FLOWMETER
electronic model

For the measurement of instantaneous rate and integrated volume of flow of liquids, the Rochar range of electronic flowmeters is now being marketed in the UK by Metrix Instruments Ltd. The magnetic induction type volumetric transducers are accurately machined from heavy duty alloy designed to withstand corrosion. Operating temperatures from -200°C to $+150$°C are permissible and models for use at higher temperatures are under development. The

The rate of flow and the volume for any given period is measured by the Rochar electronic flowmeters which are capable of operating from -200 to $+150$°C

transducers are small, easy to install and are free from vibration, may be positioned anywhere in the line and not affected by the pressure of liquid flowing. The signal from the transducer is fed to a frequency meter, with a pulse shaping circuit and an output meter calibrated in terms of rate of flow. An auxiliary circuit provides an output pulse for every complete unit of volume which is fed to a mechanical counter to indicate the total volume of flow at any time. The range of flow rate covered by these instruments is from 4·4 to 22,000 gallons.

Tick **No 218** on reply card

MOTORIZED GEARS
variable speeds

A new range of vertical flange and foot mounting gearboxes have been introduced by Electropower Gears Ltd. By simple change lever, two or three speeds can be obtained and if used in conjunction with 2, 3 or 4 speed electric motors, up to twelve output speeds may be ob-

tained. Various sizes are available covering a power range of between ¼ and 150 h.p. and reversing gearboxes are also available for the same power ratings. These units can be used on their own, driven by a prime mover through either a belt drive or coupling and if required may be used in conjunction with Slo-Rev units to give stepped speed variation at very low revolutions.

Tick **No 219** on reply card

INERT THERMOPLASTIC

high resistance values

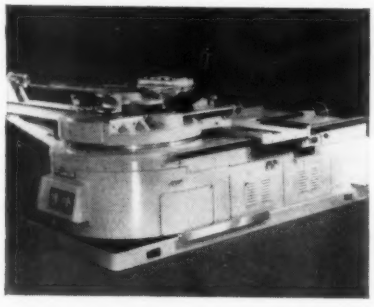
A new engineering plastic, Polypenco K.51, has been introduced which possesses an unusual combination of properties for a thermoplastic—good dimensional stability and mechanical strength with chemical and high temperature resistance. It is inert to almost all alkalis, solvents, chlorides and inorganic acids and having a tensile strength of 6000 lb/sq in. with a Rockwell hardness of R100, it is suitable for such applications as bearings, valve seats, impellers and seals operating under severe corrosive conditions.

Tick **No 220** on reply card

TUBE BENDER

for heavy duties

The chief requirements in the design of a heavy duty bender and on which the production of good quality bends depends are absolutely rigidity and ample power. In the new MSA.6 unit, manufactured by Hilmor Ltd., these characteristics are fully catered for by the use of a massive foundation and an all-mechanical 15 hp drive from a sliding rotor



Capable of dealing with many forms, including finned, of steel tubing up to 6 in. in diameter, the Hilmor MSA.6 will produce standard or short radii full bore bends

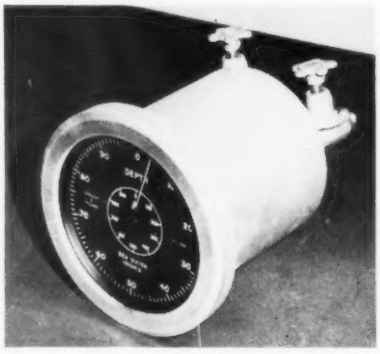
brake motor. The bending head and clamping mechanism are of new design providing rigidity and freedom from give. To achieve this, the tube grip clamp and the pressure die housing which transmit the whole of the bending effort are mounted directly on the body of the machine. The unit is fitted with a hydraulic mandrel extractor with sufficient stroke to permit the use of articulated mandrels and with an adjustable bracket to carry wiper dies. The maximum capacity of this bender is 6 in. bore heavy gauge mild or stainless steel tubing and 8 in. bore non-ferrous tube. It can be tooled to bend square, rectangular, oval and other forms of non-round tube, finned tube, angles, bar, extrusions and open sections.

Tick **No 221** on reply card

H_2O PRESSURE GAUGE

works as depth gauge

To meet an Atomic Energy Authority's requirement for a depth gauge, Appleby & Ireland Ltd. have produced a 0-1000 in. H_2O instrument based on their Type AI.101 Multi-turn Absolute Pressure Gauge. Having a standard accuracy of



Compensating for barometric and temperature conditions over the full scale range, the Appleby & Ireland A1.101 pressure gauge is used by AEA as a depth gauge

± 1% full scale deflexion, the instrument has a 6 in. dial presentation, the scale graduation being 0-100 in. H_2O per revolution of the large pointer with a small pointer indicating each 100 in. up to 1000 in. pressure.

Temperature and barometric compensation over the scale range can be provided and where the gauge is required as a master, the accuracy can be established at ± 0·3% full scale deflexion.

Tick **No 222** on reply card

DECADE SCALERS

for nuclear research

Hamner Electronics of New Jersey announce the N-220, a low-cost, fast counting device using three incline decades and a four-digit electromechanical register with a time resolution of 1 microsecond. Preset count is 10, 100, 1000. Accessories include L-F Timer, plug-in RF power supply and amplifier. Discriminator range is from − 50 to + 100 volts with an alternate choice of low-level discrimination of from − 10 to −0·25 volt for GM use, and increased sensitivity of 1 mV is available with the addition of a plug-in amplifier.

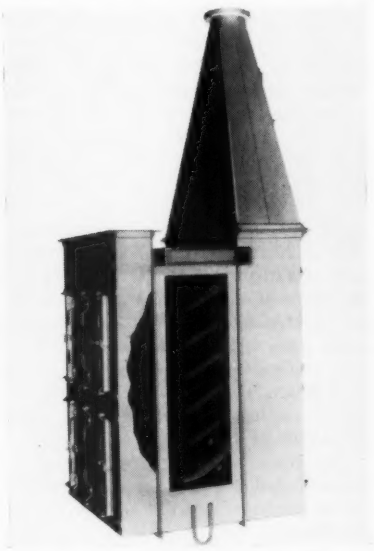
A unit with manual and preset time, the Hamner N-230 is also available.

Tick **No 223** on reply card

CYCLONE COLLECTORS

hold fine dusts

Economies in capital and operating costs have been achieved in the D.584 Mancuna-Dustex collector by providing a high gas volume per cyclone tube with a reduced pressure resistance. Made by Mancuna Engineering, the unit comprises of a number of standard cyclone tubes incorporating the scroll inlet in one single casting per tube. The tubes are cast with a $\frac{5}{16}$ in. wall thickness and are available in stainless steel, aluminium alloy, or in



Operating at 4 in. WG, the Mancuna Dustex unit removes all particles 14 microns and larger and permits a higher gas volume with reduced pressure resistance

an unannealed malleable white iron with a very hard working surface and high resistance to abrasion. The tubes are located in the clean air stream which maintains them at system temperature and prevents condensation and any subsequent tendency to build up and blocking.

Tick **No 224** on reply card

IN BRIEF

Subminiature. Two new subminiature tubes—the HF double triode XR9 and the twin trigger cathode tube XC24—have been added to the Hivac range.

Tick **No 225** on reply card

Conductivity bridge. Lock instrumentation announce a transistorized conductivity bridge operating at high frequency from a long-life dry battery. It covers the wide range of 0·5 micro-ohms to 1 × 10 micro-ohms in six ranges.

Tick **No 226** on reply card

INDUSTRIAL NEWSDESK

CANDU test loop completed

A 500,000 dollar test rig for nuclear reactor components has been completed by Humphreys & Glasgow (Canada) Ltd., at Toronto for the Nuclear Power Plant Division of Atomic Energy of Canada, Limited. The rig is installed at the A. W. Manby Service Centre at Toronto of the Ontario Hydro-Electric Power Commission and consists of two test loops, each basically a water-circulating system capable of being operated at the high temperatures and pressures encountered in nuclear reactors. They will be used primarily for testing equipment and components having a direct bearing on the CANDU reactor programme.

It occupies a ground-floor area of about 5000 sq.ft. An existing mezzanine floor at 20 ft elevation and a new platform at 8 ft provide service access to the rig. The ends of the loop manifolds on the rig stretch almost 100 ft, while the centre lines of the manifolds run parallel to one another, and for each loop are 28 ft apart. The rig was commissioned and in use only eight months after commencement of design.

Two basic types of experiments will be conducted on the rig. In one, heat will be produced at a constant rate in an experimental test section to study heat transfer characteristics of the heating element. The temperature of the circulating water will be regulated by 'dumping' heat in excess of that generated and then controlled by an electric heater, external to the test section.

The second type of experiment involves no heat input from the test section and the temperature of the water will again be controlled by over-cooling the rig and operating the electric heater on automatic temperature control.

AEA streamlines production

Engineers of the United Kingdom Atomic Energy Authority have shown great ingenuity in reducing the number of individual glove-boxes needed when an intricate component has to be made from a blank of radioactive material.

Basically, all the machine tools are installed in one large glove box and are mounted on a motor-operated turntable inside the box, so that any part of the working array can be quickly brought right in front of the operator. This saves having to bag the component in polythene for transfer between each machine and re-positioning the component before operations continue. Also, overall glove box space is reduced.

This rotary line, as it is now known, has proved so successful that it has been adapted for laboratory operations at Harwell, where the turntable is operated by hand and facilities are incorporated for joining a number of boxes together.

These units are now being considered for use in the machining of beryllium on a semi-industrial production basis for fuel cans. Another potential application is when the time comes to set-up industrial-scale production lines for plutonium-based fuel elements.

HANDLING SPENT FUELS. The control desk of one of the two Savage & Parsons power-operated manipulators installed by the AEA at Windscale for the continuous remote handling of spent elements from Calder Hall

The AEA have granted licences to manufacture these new glove boxes to the Seton Creaghe Engineering Company Ltd. and the Boucher Company Ltd.—possible commercial applications include the sterile processing and packaging of antibiotics.

First Latina boiler ready

At the end of this month, the Nuovo Pignore di Massa works will have completed the first of the six heat exchangers they are making for the Latina nuclear power station, under contract for AGIP-Nucleare. Following cooperation with NPPC and with British supervision, the Massa works' construction methods and standards of fabrication have now been fully approved by Lloyd's.

High fuel efficiency

The results of a series of recent oxide fuel element tests conducted by US General Electric in its Vallecitos Boiling Water Reactor revealed that of 500 fuel segments irradiated in the reactor since late 1957 only two have failed. Both were of preliminary design and contained high-density uranium dioxide pellets. The fuel failures did not result in permanent contamination of the system and radioactive carry-over is not a serious problem. Maintenance following shutdown was not limited by the small amount of contamination that did result.

In these two cases the rupture affected only one segment from a total of 18 in a fuel assembly bundle and fabrication processes are being improved to the point where fuel element failures will be very unlikely.

Fuel segments purposely made defective were also tested and no contamination problem in either the reactor coolant or the turbine generating system was experienced. In this test, several defective fuel elements were put into an assembly, which was placed in the reactor core for six days while the reactor was operated at full power. Experiments are continuing using assemblies containing deliberately defective fuel elements to study performance under various reactor operating conditions.

Piqua containment started

A contract for the containment structure for the Piqua, Ohio, nuclear power plant has been awarded by Atomics International to Graver Tank and Manufacturing Co., Division of Union Tank Car Co., marks the beginning of the second phase of this project and follows completion of the excavation work last month.

The containment structure will be 123 feet high and 73 feet in outside diameter. The gas tight structure will be dome-shaped, lined with concrete and will provide an additional safety feature of the low pressure reactor system and will shelter the reactor as well.

The contract calls for the containment structure to be completed 30 weeks after settlement of the US steel strike.

Atomics International is building the organic moderated and cooled reactor designed to produce 11,400 kilowatts of electricity for the City of Piqua, under contract to the Atomic Energy Commission. It is expected that the reactor will be completed and tested by October, 1961.

46 attend Argonne course

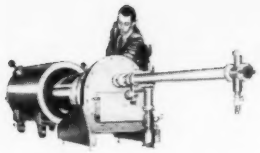
Forty-six scientists and engineers from 21 foreign countries and the United States arrived at the United States AEC's Argonne National Laboratory, Monday, August 17, to begin a 20-week course on nuclear reactors, their design, construction, instrumentation and use.

They are participants in the Ninth Session of the International School of Nuclear Science and Engineering at Argonne and represent Belgium, Brazil, China, Ecuador, Finland, Germany, Greece, India, Iran, Israel, Italy, Japan, Korea, the Netherlands, South Africa, Spain, Sweden, Thailand, Turkey, the

VERSATILE ACCELERATORS for fundamental or applied NEUTRON RESEARCH

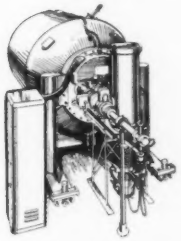
●

NEUTRON SOURCES now available from High Voltage Engineering Corporation range from compact, low-cost Van de Graaff positive-ion accelerators to large linear electron accelerators for energies up to 100 Mev and higher.



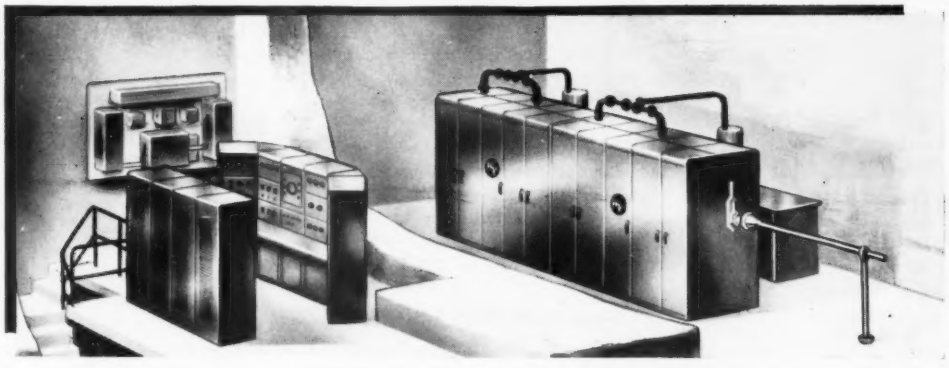
PN-400 Van de Graaff — Lowest cost. Ideal for reactor engineering, nuclear training courses, pulsing subcritical assemblies.

Pulsed or continuous operation.



KN Van de Graaff — Powerful and precise for broad research programs including nuclear physics, advanced neutron work, biology, reactor engineering, and activation analysis.

Pulsed or continuous operation.



LS Series Linear Accelerators — Electron energies of 6 Mev and above. Optimum neutron yield per kilowatt obtained above 30 Mev. Useful for nuclear physics, neutron-damage studies, time-of-flight research, high-energy radiography. High flux density suitable for isotope production.

Model	Particle Energy Mev	Pulse Current milliamperes	Total Neutron-yield Rates during Pulse	Pulsing and Repetition Rates
PN-400	0.4	0.10	10^{10} n/sec †	μsec range 1-10,000 pps
KN	3	0.40	2×10^{12} n/sec ‡	millimicrosecond to μsec range; 1-10,000 pps
LS Series Example	40	350	10^{14} n/sec *	0.01-10 μsec 1-2500 pps

† T(d, n) He^4 reaction
‡ Be^9 (d, n) B^{10}

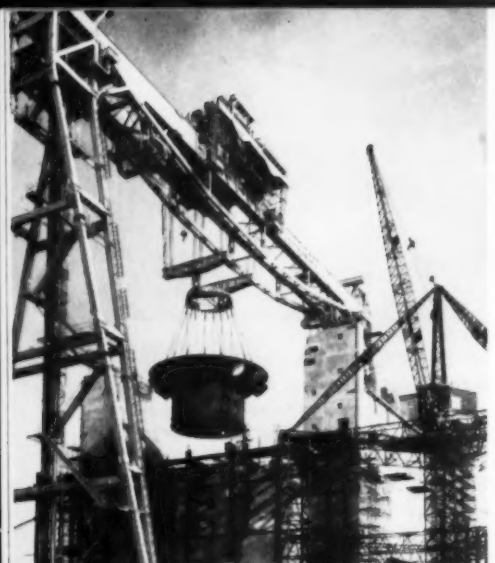
* Photo-nuclear and photo-fission reactions.

Other accelerators rated for operation at intermediate and higher outputs, are also available. Write High Voltage Technical Sales Department for specific performance data

HIGH VOLTAGE SERVICING COMPANY LTD.
60 Carpenters Wood Drive
Chorley Wood, Herts.
Telephone Field End 7431

HIGH VOLTAGE ENGINEERING
CORPORATION
BURLINGTON, MASSACHUSETTS, U.S.A.

Tick **No 82** on reply card for further details



PROGRESS AT HINKLEY POINT. During September the first section of the 67 ft diameter steel pressure vessel was lifted into the completed shell of No. 1 reactor

United States, Vietnam, and Yugoslavia.

Jacobus Wynand DeVilliers of the South African Atomic Energy Board, Pretoria, and Nguyen Quang Dong of the Office of Nuclear Energy of the Republic of Vietnam, Saigon, are the first representatives of their countries to attend the International School.

Ekco Electronics tour Europe

Following last year's sales promotion tour in Scandinavia, Holland and Belgium, the Ekco Electronics mobile demonstration unit is now touring southern Europe. Starting at Bilbao, on September 1, the tour embraces Spain, France and Italy when their nucleonic gauging equipment will be demonstrated to industrialists in many large towns on the route. Opportunity will also be taken to supervise the installation of Ekco gauges, already delivered, in Bilbao and Barcelona. The demonstration unit is expected to end its tour in mid-October when an exhibition will be staged in Brussels by Physique Industrielle, Ekco's Belgium distributors.

Engineers move into Hallam

In just over a year, since work first started, most of the foundations and heavy civil construction are nearing completion on the Hallam Nuclear Power Facility, HNPF. Installation of the heavy mechanical engineering equipment has started and this 75 MWe sodium-cooled, graphite-moderated reactor is scheduled for completion in 1961. Atomics International, the main contractors, personnel will carry out commissioning and start-up, after which the HNPF will be operated by the Consumers Public Power District of Nebraska.

John Brown still cautious

Despite their contract with the UK Atomic Energy Authority for the design and manufacture of the refuelling machine for the AGR, the Chairman of John Brown & Company Ltd. has indicated that while his company is watching the application of nuclear power with interest, its approach remains cautious.

Their subsidiary, Constructors John Brown Ltd. are making a more positive approach and are developing their process for producing heavy water from ammonia, which was introduced at Geneva last year.

Amplifiers for Berkeley

After designing and making magnetic amplifiers for aircraft engines, over the past fifteen years, the Special Products Division of Ultra Electrics Ltd. has developed these components for use in nuclear reactor control systems. As a result of this work, high-stability magnetic amplifiers are now being supplied to British Thomson-Houston Ltd. for use in the Berkeley nuclear power station.

Following the formation of Continental Connectors Ltd. to make and sell the electrical connectors marketed by the Continental Connector Corp. of New York, Ultra Electrics have been granted the manufacturing and selling rights for the UK, the British Commonwealth, Europe and Asia and they have set up a new division to implement these activities.

Hawkers take over AEA plant

The UK Atomic Energy Authority's West Howe Factory, located between Bournemouth and Poole, is to be operated by the Hawker Siddeley Nuclear Power Co. Ltd. The work carried out at this plant will include design, manufacture and life-testing of reactor equipment. The main objective of this work, at West Howe, will be to provide the AEA's Winfrith establishment with facilities and staff for the development, testing and maintenance of mechanical engineering equipment for Winfrith's reactors and associated installations.

New glove box hoist

A special remotely controlled glove-box hoist has been designed and is being produced by the Hawker Siddeley Nuclear Power Co. Ltd. In its present form it has a lifting capacity of 3 cwt and such loads can be lifted 5 ft at speeds ranging from 0 to 12 ft per minute. The unit height from the top of the channel rails supporting it to the centre line of the hook is only 14½ inches, considerably less than that of normal hoists for the same duty. When gantry mounted, the hoist hook can drop to within 7 inches of the ends of a glove box or similar housing and to within 10 inches of its sides.

Still more aircraft facilities

Despite criticism in Congress of the cost of the American nuclear powered aircraft projects (see *Worldview*, last month), recent contracts placed by the US Atomic Energy Commission include several covering extensions to the aviation-side of the National Reactor Testing Station at Idaho. Fischback and Moore Inc., of Seattle, have been awarded a $495,000 order for installation of instrumentation systems for the Flight Engine Test Facility—radiation detection and stack gas monitoring equipment is included in the materials to be installed.

A contract, worth $461,370, has been awarded to Teller Construction Company, of Idaho Falls, for the construction of a Technical Service Laboratory in the station's Aircraft Nuclear Propulsion area. This company has also received another contract, valued at $71,765, covering buildings for the Stationary Low No. 1 Reactor in the US Army Reactors Area.

Cheaper synthetics

Midland Silicones have announced another reduction in the price of Silastic LS-53, a fluorinated silicone rubber which is serviceable from −60°C to over +200°C. This new price cut of 10% is in addition to two other price reductions which have taken place over the past twelve months, making a total reduction of a third since then.

Since its introduction to the market in 1957 it has met the need for a heat-stable rubber for use in industries where rubber parts are exposed to oils, fuels and hydraulic fluids at extreme temperatures.

This price reduction falls in line with similar cuts announced recently by the UK makers' associates Dow Corning Corporation of America, who developed and manufacture Silastic LS-53.

Up or down?

The difficulties confronting industrial organizations engaged in manufacturing nucleonic instruments are well exemplified by recent announcements from the US company, Tracerlab Inc. Operations in the first six months of this year resulted in a loss of $227,000, although the company, after receiving various classified government contracts valued at nearly $600,000, has a $M3½ backlog of

SPICK AND SPAN WITH

NEWSPAN

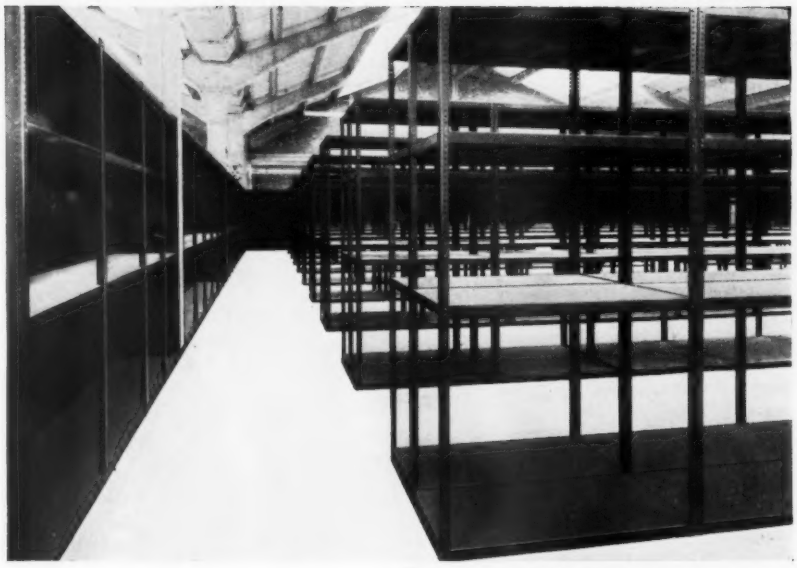
However chaotic your storage problem, NEWSPAN will reduce it to order, quickly, cheaply and efficiently. With NEWSPAN you'll find you end up with far more storage space than you began with!

NEWSPAN Punched Angle Uprights come in five standard heights, from 72″ to 120″, or in any height you specify.

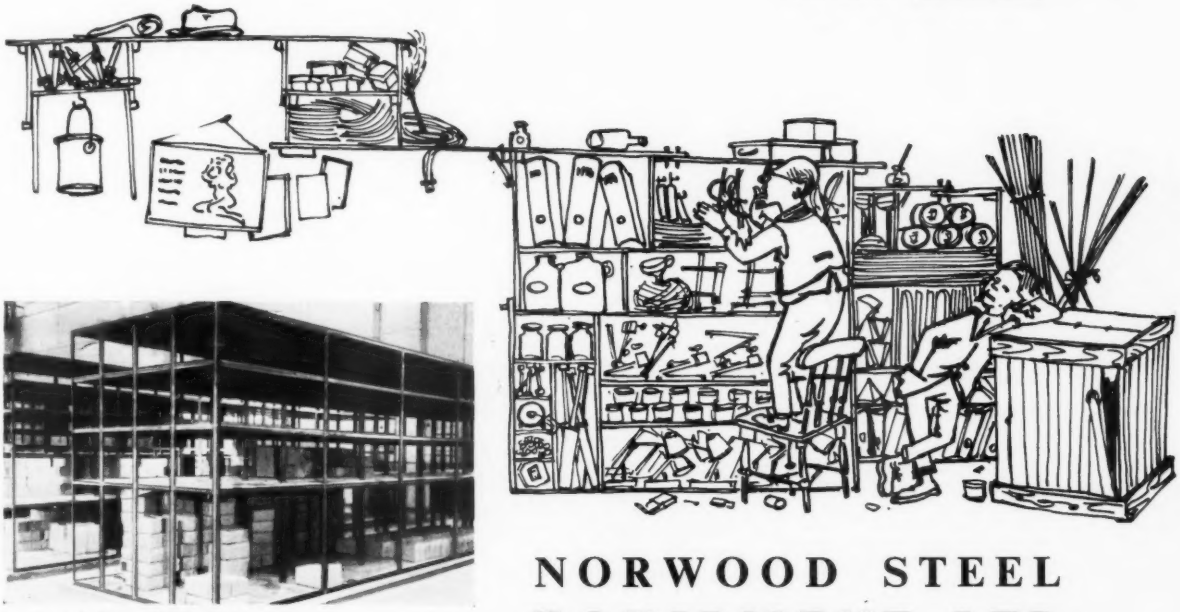
NEWSPAN shelves come in eight standard sizes, from 48″ by 9″ to 96″ by 42″. Any combination of these sizes can be supplied, also shelf reinforcement to suit your loading, up to a maximum of 3,000 lb. per shelf.

NEWSPAN gives you over 350 combinations of rack sizes from Standard Parts.

Tell us your problem—we will propose a solution in NEWSPAN. We have a new illustrated brochure available. Please write for a copy.



Tesco Stores' food warehouse



Bristol Aircraft Co. Ltd.

NORWOOD STEEL EQUIPMENT LTD

149 Borough High Street, London, S.E.1. HOP 5033

Tick **No 83** on reply card for further details

orders and working hours per week have had to be increased to expedite completion of these orders.

At the same time, Tracerlab has cut by between 20 and 25%, the cost of three of the most commonly used geiger tubes—those of the survey, dip and industrial types. Parallel with these reductions, they have made available from stock, radioactive clathrates which combine unusual safety characteristics with high specific activity (see *New Products*, this month). The overall effect of these activities are, it is hoped by the company, to result in small profits accruing by the end of the year.

Fetching prices down

In recent weeks, news of improved production methods continue to come in and with them, announcements of price reductions. Quasi-Arc of Bilston are, on and after October 1, reducing the price of their mild steel electrodes.

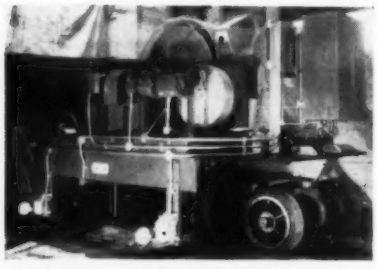
Following the introduction of 'production line' manufacturing methods for Holmes-Connerville Positive air blowers, considerable savings in costs have been achieved and these are being passed on in the form of reduced prices. In some instances, these reductions are almost twenty per cent for machines that have a capacity of up to 110 cfm at pressures up to 59 lb/in².

American MTR output

Advance in cancer therapy has resulted from one of the activities at the Materials Testing Reactor which Phillips Petroleum Company operates for the US Atomic Energy Commission at the National Reactor Testing Station near Idaho Falls, Idaho.

For almost four years a slug of cobalt was exposed to intense neutron flux in the reactor and, in November, 1957, this source was shipped to the Argonne Cancer Research Hospital in Chicago, which is now reporting very high cure rates.

The cobalt source, of 2794 curies, is a metal rod a little over one inch long and one-third of an inch in diameter, weighing less than one-half ounce; it is equivalent in terms of radiation to over six pounds of radium. Another cobalt source presently being irradiated at the MTR could be ready for the Hospital's use within two years.



MOVING SHIELDING BLOCKS. Two special transporters for the AEA's 7GeV Proton Synchrotron have been built by Robert Hudson Ltd. Below is the general arrangement of the complete unit, made up of four transporters and a power pack. Above, by hydraulic jacking, lateral movement is possible in place of the normal longitudinal traversing

Further education

Both in the UK and the States, several additional facilities are being initiated this autumn in the field of nuclear technological training. The American AEC have organized a two-week course in nuclear safety, beginning September 21, at Oak Ridge, Tennessee. The course will emphasize the prevention of criticality in the handling of fissionable materials.

To provide students of small undergraduate colleges with the opportunity for specialized training in techniques in the use of radioisotopes, the AEC are starting a programme of short concentrated courses. As it is particularly intended to serve the smaller colleges whose nuclear facilities are limited, a mobile training laboratory will be employed.

In London, three courses will start at the beginning of October. The London County Council have organized a short course of six lectures—an introduction to nuclear physics for engineers—at the South East London Technical College and will commence on October 6. A more advanced programme has been included in the 1959–1960 session of the Northampton College of Advanced Technology, where a two-year course on Nuclear Power is conducted. The first section covers 'An introduction to Nuclear Power' and the second 'The Engineering Design of Nuclear Power Plant', both of which start early in October. All the London courses are designed to suit practising engineers and technicians interested in this field of engineering and are, accordingly conducted in the evening.

Allied to nuclear technology, the Institution of Plant Engineers are holding their comprehensive refresher courses at Leeds University during the coming winter. Special emphasis is being given to new materials and techniques, developments in welding practices and trends in future plant design.

Future uranium needs

The US Atomic Energy Commission have announced that details of uranium ore reserves, which should have been submitted to them by July 31, may now be tendered by October 1. Is this indicative that the reserves are not as much as anticipated? This information is needed in connexion with the contract negotiations that are at present being conducted for the supply of uranium concentrate through the calendar year 1966.

To develop and mine Western Fluorite uranium properties in the area of Stanley, Idaho, and explore and develop other properties, a new company, Vitro Idaho Minerals Corp has been formed by the Vitro Minerals Corp. and the Western Fluoride Mining Company, with 51% and 49% holdings respectively.

MOST POWERFUL IN EUROPE. The First Lord of the Admiralty, the Earl of Selkirk, at the control console of EMI's largest analogue computer at Armstrong Whitworth Aircraft Baginton works

AEA seeking beryl

Although the present output of beryl in Uganda is small, this mineral is already being used in the production of material for nuclear power, high speed flight and guided missile components. For some time experts from the United Kingdom Atomic Energy Authority have been at work endeavouring to assess the potential of the mineral in the Protectorate and improve methods of extraction. The mineral is mined over a wide area of Ankole and Kigezi districts in Western Uganda and is at present purchased by the British Metal Corporation Limited for the AEA.

Mainly discussions

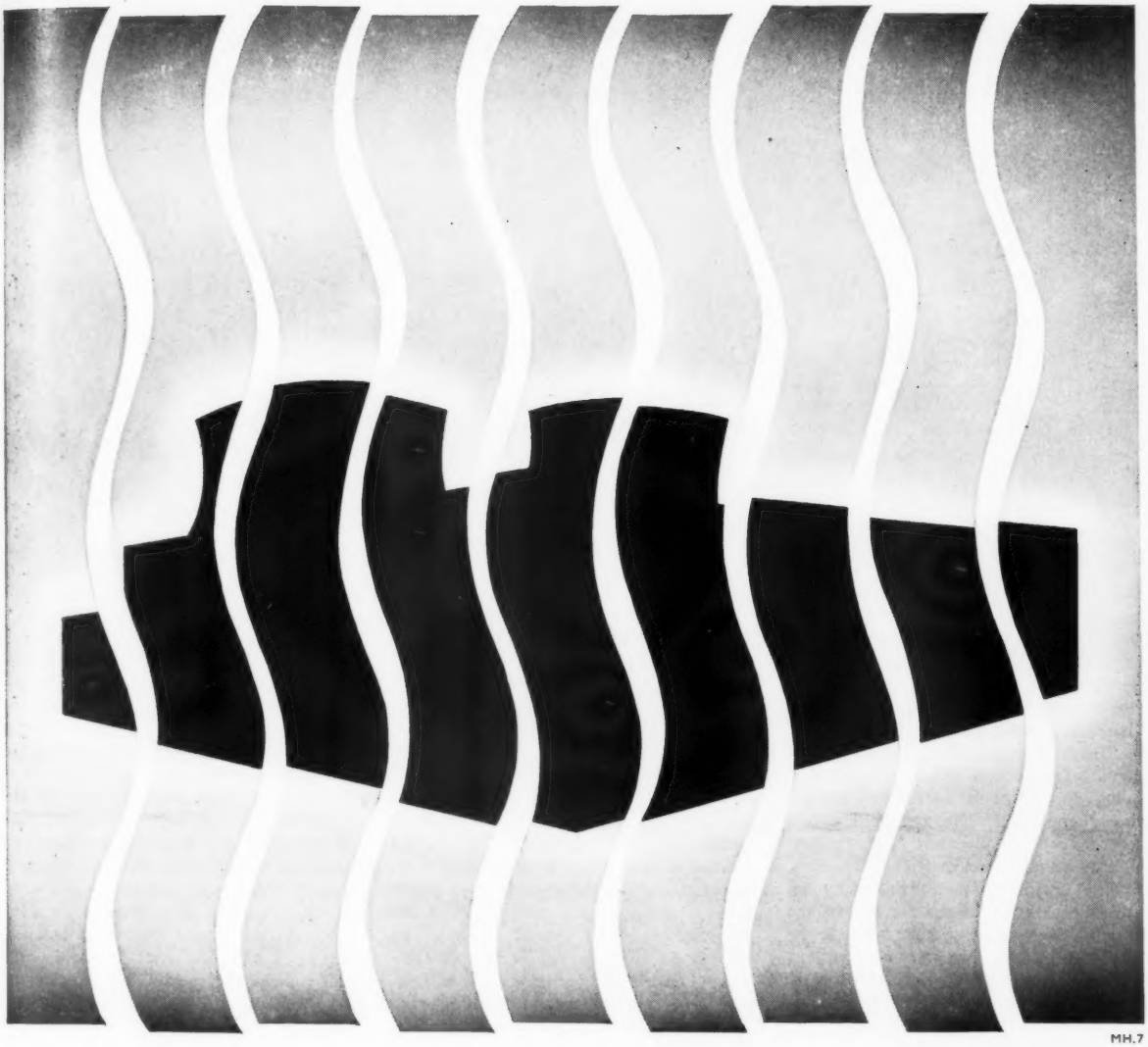
Germantown, Md. On October 1, the AEC are holding a symposium for industry on the development and potential industrial uses of reactors for the production of low temperature process heat.

Newcastle-upon-Tyne. The North East section of the Institution of Plant Engineers will be holding a meeting on October 8, when the subject will be 'Recent Developments in Steelmaking Process.'

Blackburn. The Institution of Plant Engineers will discuss 'Operational Research in the Steel Industry' at their meeting on October 15.

Richland, Washington. The United States AEC is sponsoring a two-day symposium for management and technical personnel on the reprocessing of nuclear fuels, on October 20 and 21.

Put Darlington insulation on...



MH.7

...wherever waste heat comes off

In atomic power stations and oil refineries, in ships and schools and sealing wax plants, Darlington Insulation is cutting heat losses, reducing fuel consumption and saving money for industrial and commercial firms of all kinds.

With Darlington Insulation you can reduce your heat losses by up to 90%—and that means big savings on your fuel bill. Whatever your heat waste problem, there is a Darlington insulating material that can solve it. Why not ask our Technical Division for advice and assistance? Simply write to:

THE CHEMICAL & INSULATING COMPANY LIMITED

Darlington, Co. Durham *or telephone Darlington 3547*

THE CHEMICAL & INSULATING CO. LTD. IS A MEMBER OF THE DARLINGTON GROUP OF COMPANIES

They said...

points from papers, speeches, conferences

AEC to rewrite their new site requirements

Uproar

Over the past five months, while legislation has been introduced in the UK covering licensing arrangements of nuclear installations, which passed almost without comment, proposed amendments to the United States laws on the same subject have caused an uproar in all fields of nuclear technology.

The two amendments, Part 20 and 140, are concerned with nuclear power and testing reactors' site evaluation, maximum permissible human radiation doses and the minimum amount of financial protection to be provided by reactor operators.

Though the AEC reviewed the factors concerned—the exclusion distance, that is the area around the reactor which will be under the reactor owner's complete control; population density of surrounding areas; weather, surface waters and underground waters, the permeability and depth of the soils and their capacities to remove and retain reactor effluents—the Commission said that only a general statement is possible at this time concerning site criteria and further work is being done. But at least these amendments are believed to represent a first step towards development and publication of complete site criteria.

These feelings were not shared by the builders and users of reactors and by the end of the original period allowed by the AEC—thirty days—88 observations had been submitted. It was subsequently agreed that such comments could be tendered up to the end of August. By this time, the American authorities had received more than 140, from state and public organizations (28), research establishments, hospitals and colleges (34), electricity generating groups (10), reactor builders and nuclear fuel element manufacturers (24), insurance companies (4), industrial laboratories using active materials (17), instrument makers (4), and miscellaneous professional and industrial organizations (28). In the main, the proposed amendments were strongly criticized.

Where not to put a reactor

On the subject of site criteria, the public authorities were generally in agreement with the AEC, but industry, both builders and users of reactors, was strongly against the proposals. The points most contended are those relating to the exclusion area which is to be under the absolute control of the licensee, suggested as a maximum radius of ¼ mile for test reactors and ½ to ¾ mile for power reactors, and location/population density requirements, proposed as 10 to 20 miles from large towns for power reactors.

Dr. Chauncey Starr, Vice-President of Atomics International, makes the point that 'the present technical state of the

CHAUNCEY STARR
not ready yet

art does not permit quantitative type regulations such as those contained in the exclusion distance and population density sections of the proposed rule. Regulations which automatically prohibit the construction of a reactor at any site should be avoided. The impact of arbitrary population criteria would undoubtedly have a great effect upon the European market for the sale of US-made reactors because of the extremely high population densities of the majority of the Western European nations, and the fact that in view of the relatively advanced state of US technology, criteria used here will be seriously considered for guidance in Europe.'

Almost identical opinions were expressed by Mr. Philip Sporn, President of the American Electric Power Service Corporation.

These points were taken further by John P. Gallagher, of John P. Gallagher & Associates, in his reference to marine and aeronautical applications when he said 'logically if such an amendment was passed, it would also seem that nuclear powered marine vessels, both military and civilian types, should not come within 20 miles of any town or city. The next step in such a programme would logically be to review the question of nuclear aircraft propulsion with the same type of thinking. . . .'

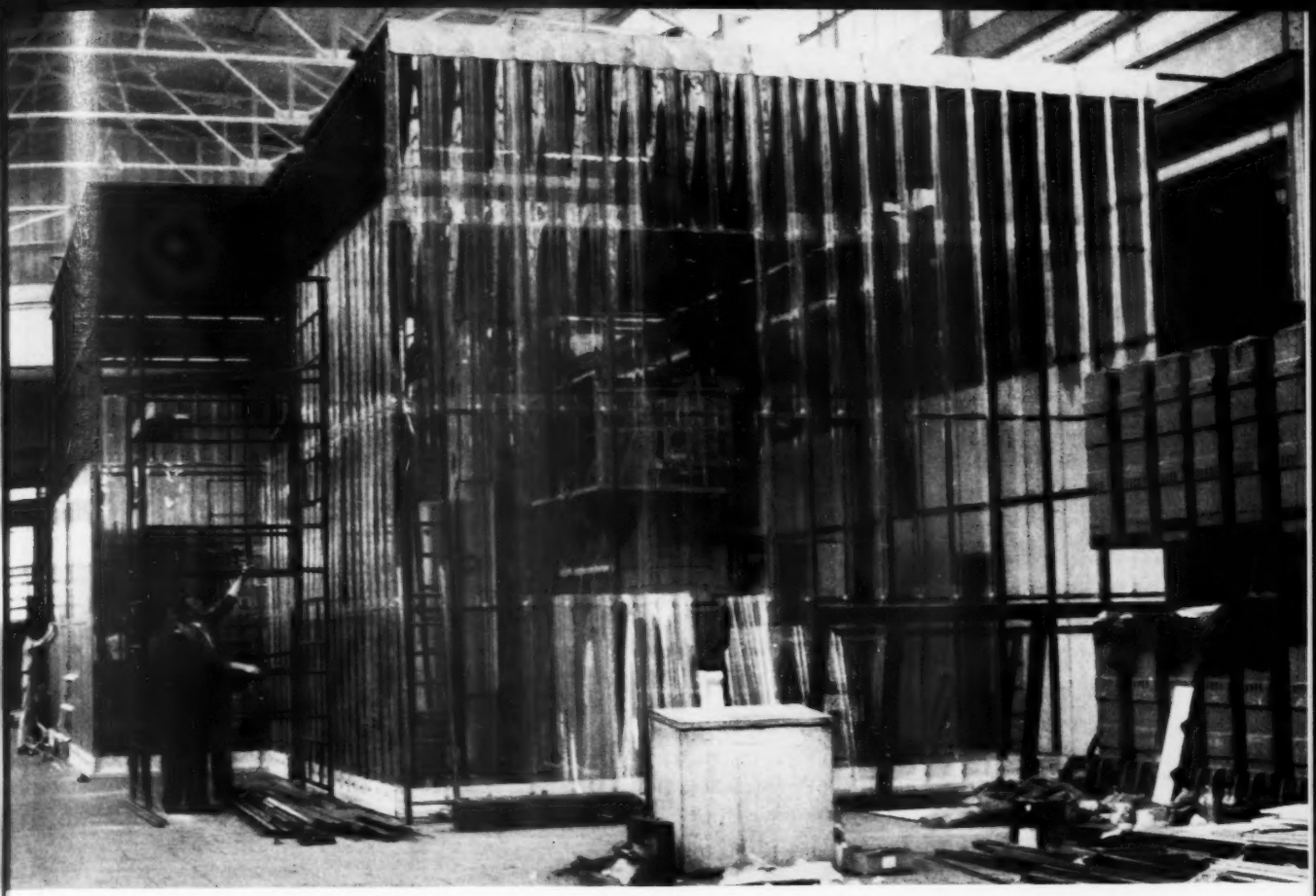
The American Hydrotherm Corp. pointed out that the proposed rule, if passed, will make it impossible to use reactors for any process or space heating service whatever. The present proposals do not make it possible to determine whether or not a reactor may be located adjacent to a factory—nor to the effect on the operator's obligations if a large factory is subsequently set up close to the reactor. Other siting problems involved include water control and although the licensee is expected to exercise his authority over the users of roads, railways and airfield runways in the vicinity of the reactor, no reference is made to river or canal traffic which, more than likely, will be equally within the area of exclusion.

Excessive cost of protection

Operators and owners of installations were of one voice in their opinion that the recommended financial protection was much too high. Mr. W. M. Cousins, Vice-President of the Armour Research Foundation said 'Our objection to the $M1½ minimum (for their 100 kW reactor) coverage specifically arises out of the unreasonable cost of that amount of nuclear insurance coverage. We recognize the difficulty in assessing what the minimum requirements should be to begin with without any consideration for relative safety factors.'

These opinions were echoed by Mr. T. G. LeClair, manager of research and development at the Commonwealth Edison Company, who said that his company's principal objection lies with the requirement that a licensee of a large reactor, that is one with a capacity of 100 MWe or more, must maintain financial protection for the specified amount of $M60, without any provision for adjustment in the event of the amount of insurance available being reduced. The proposed form of liability insurance policy provides for the cancellation of the policy without cause on 30 days notice and suspension of the policy on 12 hours notice—this leaves the licensee liable to provide the full coverage under this amendment out of his own resources!

The only really firm support came from the insurance companies, who, in the form of the Nuclear Energy Liability Insurance Association, NELIA, and the Mutual Atomic Energy Liability Underwriters, MAELU, stated 'in view of the amount of insurance available from NELIA and MAELU as well as the amounts of liability insurance commonly purchased by industrial concerns engaged in hazardous occupations, we regret that the Commission has elected to fix such low levels of financial protection.'



another problem solved with UNISTRUT

Insulated enclosure for machining 7GeV synchrotron core

An unusual temperature control problem was encountered by Messrs. Joseph Sankey Ltd. in the machining of 336 sectors, each accurate to within half of one degree, which will form the core of the Commonwealth's largest electro-magnet. When assembled, this will measure 160 ft. across, yet the throat faces must be parallel to within .004 inches.

2,700 sq. ft. Unistrut enclosure

To ensure dimensional stability, machining takes place in an insulated booth where the temperature has a maximum variation of 0.75° C. Measuring 80 ft. x 34 ft. x 20 ft. 9 in., with three sliding hatches and four 20 ft. high Unistrut doors for introduction and removal of the two-ton sectors, the booth consists of a Unistrut framework, incorporating a 27 ft. truss also of Unistrut: it is clad on three sides with Perspex, on the fourth with Menotex sheeting, and roofed with Asbestolux.

No interference with production

The framework itself was rapidly assembled using standard Unistrut channels and self-locating nuts; the members are spaced to accept standard sized sheets with little or no cutting, thus conserving material and reducing on-site labour costs. The entire installation apart from the hatches was completed in one week-end, avoiding production hold-ups. As the enclosure will be required in its present form for only twelve months, Unistrut's facility for layout alterations is an added advantage; alternatively, the structure can be entirely dismantled and its materials freed for other use.

Wide range of applications

'Space division' is only one field in which Unistrut's rapid, rigid assembly and wide component range assist planning and reduce on-site time and cost. For further information on its use in pipe support, electrical trunking, instrument mounting, etc., please write to the address below.

UNISTRUT STEEL CHANNEL FRAMING SYSTEM

Unistrut Division of Sankey-Sheldon Ltd. A member of the Guest, Keen & Nettlefolds Group of Companies

43-45, Broadwater Road, Welwyn Garden City, Herts. Telephone: Welwyn Garden City 6321 (4 lines)

UNI306

NAMES IN THE NEWS

A serious loss to the Atomic Energy Authority is the move to industry of **Mr. J. R. V. Dolphin,** C.B.E., at present chief engineer of the Research Group. On December 1 he becomes joint managing director of Lansing Bagnell Ltd., of Basingstoke, who specialize in mechanical handling equipment. Before joining

J. R. V. DOLPHIN leaves atomic energy

the AEA, Mr. Dolphin built up an impressive record of mechanical engineering inventions, including a coal cutter chain now in general use in mines throughout the world, two midget submarines accepted by the Admiralty, and a folding motorcycle for parachutists. He has been in his present post for two years during which he was entirely responsible for the construction of Winfrith Heath. Before that he was chief engineer at Aldermaston in charge of the bomb.

Mr. J. E. Robson, M.C., has been appointed to the board of Samuel Osborn & Co. Ltd., Sheffield.

Mr. F. W. Stokes, works manager of Powell Duffryn Carbon Products Ltd. since 1954, has been appointed to the board. Over the past two years he has

F. W. STOKES enters Powell Duffryn boardroom

been working on graphite machining problems and has designed many of the special tools and machinery required, including a trepanning device for fuel element sleeve manufacture. At the moment the company are machining the sleeves for Bradwell and production on the struts for Hunterston will begin at the end of the month.

Mr. A. L. Ayton has retired from the position of secretary of Keith Blackman Ltd., and the Blackman Export Co. Ltd., after celebrating fifty years with the company. He retains his seat on the board of directors of both companies. **Mr. E. W. A. Richards** became the new secretary on September 1.

Mr. Robert E. Hollingsworth has become deputy general manager of the US AEC. He has been with the Commission since 1947 successively in the Finance, Production, and Administration Divisions.

Mr. R. S. Medlock, technical and home sales director of George Kent Ltd., has been elected president of the Society of Instrument Technology.

Dr. W. E. Frahn has been appointed to a new chair of nuclear physics in the University of Stellenbosch, SA, from January 1, 1960. He is now first research officer in the department of nuclear physics of the CSIR National Physics Research Laboratory in Pretoria.

Mr. David M. Checkley, former general manager of the Industrial Engineering Division of Arthur G. McKee & Co., Cleveland, Ohio, is the new president of Vitro Engineering Co.

The new director of SIMA, **Captain R. A. Villiers,** C.B.E., took up his appointment on September 1. Now retired, Captain Villiers had a distinguished naval career which included a three-year spell in command of the Underwater Countermeasures and Weapons Establishment at Havant. From 1957–59 he was

Captain R. A. VILLIERS from NATO to SIMA

UK naval representative with the NATO Military Agency for Standardization and chairman of the Naval Board in London.

Dr. Dennistoun W. Ver Planck, currently head of the Department of Mechanical Engineering at Carnegie Institute of Technology, has been appointed assistant director of the John Jay Hopkins Laboratory of General Dynamics' General Atomic Division as from February 1, 1960.

CATALOGUES AND BULLETINS

Vacuum equipment. New range of high vacuum equipment is described in General Engineering's bulletin 110. Complete pumping plants can be supplied or custom-tailored if necessary.
Tick **No 252** on reply card

Epoxy resins. Handy chart from CIBA (A.R.L.) Ltd., details various forms of **Araldite** adhesive and the various materials with which it can be successfully used.
Tick **No 253** on reply card

Magnets. Holding and lifting permanent magnets from Darwins Ltd. are detailed in recent leaflet. Tables are included giving dimensions and holding forces.
Tick **No 254** on reply card

Low frequency generators. Leaflet from Servo Consultants Ltd. describes a new very low frequency generator type G110 and G111. The instrument can also be used as a variable speed precision drive, and if fitted with a pen recorder can be used for the investigation of harmonic response of control systems.
Tick **No 255** on reply card

PVC Plastics. British Geon's 'The Geon Story' illustrates the many and varied uses of PVC products. Of particular interest are piping for effluents and protective 'space-man' suits.
Tick **No 256** on reply card

Ultrasonic cleaning. Dawe Instrument's 'Dawe Digest' for June has an article on the ultrasonic cleaning of components of a particle accelerator at Harwell. Leaflets are also available on a transistor frequency meter and a transistor audio oscillator.
Tick **No 257** on reply card

Transmission belting. A new plastic belting called **Dixylon** is especially suitable for chemical works etc. as it can be supplied with anti-static properties. Catalogue from the makers, R. & J. Dick, describes.
Tick **No 258** on reply card

Non-destructive testing. Recent number of 'Solus Schall News' contains an article on the determination of defect size by ultrasonic pulse echo method.
Tick **No 259** on reply card

Industrial glassware. A 96% silica glass which withstands high temperatures and drastic thermal shock is the subject of bulletin B-91 issued by Corning Glass Works.
Tick **No 260** on reply card

Meehanite castings. Ten basic rules for designers, based on foundry practice, are illustrated in a colour brochure from the International Meehanite Metal Co. Ltd.
Tick **No 261** on reply card

nucleol

radiation resistant lubricants for the atomic age

A range developed and perfected by Wakefield-Dick Research

Conventional oils cannot live in conditions of atomic radiation. Such conditions are inseparable from certain parts of any mechanism designed to produce power from nuclear fission. This, and other allied lubrication problems, was the challenge which faced oil technologists everywhere. And, as so often in the past, Wakefield-Dick's research team produced the answer. An entirely new series of oils and greases, resistant to radiation and named "Nucleol", is now available to lubricate the wheels of this Atomic Age.

INDUSTRIAL WAKEFIELD-DICK LUBRICANTS

A Wakefield-Dick research chemist investigating the effects of radiation on lubricants.

Two examples of the NUCLEOL range

NUCLEOL 522 A radiation resistant lubricant based on selected mineral oils of high aromaticity and containing special inhibitors.

NUCLEOL C 120 A grease gelled with a new compound, and specially inhibited. Designed for the lubrication of control actuator bearings operating at the lower radiation levels.

Tick **No 86** on reply card for further details

NEW BOOKS
on Atomic and Nuclear Physics

(General, Advanced and Applied) Supplied from stock. Foreign books not in stock obtained to order. Catalogues on request.

SECOND-HAND BOOKS

A constantly changing large stock of Scientific and Technical Literature on view, classified under subjects.

LENDING LIBRARY
Technical and Scientific

Annual Subscription from £1 . 17 . 6. Bi-monthly list of New Books and New Editions sent post free to all subscribers on request. Prospectus post free on application.

H. K. LEWIS & CO. LTD
136 Gower St. W.C.1. EUS 4282

NUCLEAR POWER BOOK INQUIRY SERVICE

If you would like to have details of a particular book or to know whether one is published on a specific subject, fill in this coupon and send it to us. We will then forward it to the appropriate publisher or bookseller who will answer your query.

NAME .....

ADDRESS .....

.....

Details please of books on the following subjects:

.....

.....

.....

.....

.....

send to **NUCLEAR POWER, 3 PERCY STREET, LONDON, W1, ENGLAND**

Book Reviews

Part-time writing

Successful Technical Writing by Tyler G. Hicks 1958 : McGraw-Hill 294 pp Price 43s

Technical writing is almost entirely a part-time activity; inevitably, since unless the rest of one's time is spent in doing, one would have nothing to write about. Nevertheless, as Mr. Hicks shows, it can be a rewarding and even profitable activity if it is gone about in the right way. He writes as an American editor and, of course, for the would-be contributor to an American magazine. Thus all his advice might not be acceptable to some British editors. Nevertheless his method of planning and writing an article seems admirable and could be applied in any language.

'Successful Technical Writing' covers not only preparation and presentation of magazine articles, but also technical reports, instruction and training manuals, catalogues and advertising copy. The last chapters are devoted to technical book writing.

America is probably now the largest producer of technical literature in the world and it is interesting to have a really authoritative treatise on how this great industry really works. Conditions here are somewhat different but even so there are few British technical writers who would not benefit from Mr. Hicks' book. If they are aiming at an American market, I would say it is essential.

C.D.

Modern neutron physics

Introduction to neutron physics by L. F. Curtiss 1958 : Van Nostrand 380 pp Price 73s

So many advances have been made in the last few years in the study of the properties of neutrons that the author, who has been a member of the National Bureau of Standards at Washington, D.C., for many years, feels that an introductory textbook on neutron physics is now needed. However, he then automatically presents himself with a difficult problem. Since an introductory work should by definition be of manageable length, should he cover the basic elements of the subject only fairly fully or should he cover the whole field but dwell only relatively briefly on each topic?

Dr. Curtiss has chosen the latter course. Firstly, he has a short chapter describing the discovery of the neutron and outlining its fundamental properties. Then follows an account of the ways in which neutrons interact with matter and the various kinds of cross-sections are described. It is in this chapter that the fission process is discussed, but the amount of space allocated to the description of this important process is altogether too meagre in the reviewer's opinion.

The succeeding sections cover neutron sources, the ways in which neutrons are detected, methods of determining neutron energies, the production of monochromatic beams of neutrons, the moderation and diffusion of neutrons, neutron diffraction, the calibration of neutron sources and fluxes and, finally, there is a short chapter on shielding and health physics.

As might be expected from the author, the chapters on neutron sources and calibration methods are extremely well written. However, more space could have been devoted to the description of reactors as neutron sources in view of their increasing importance in this respect.

The author has made a good attempt to produce an all-embracing work on neutron physics, and the book serves as a good introduction to any reader who wishes to have a broad appreciation of the subject.

D. J. Littler

More Geneva

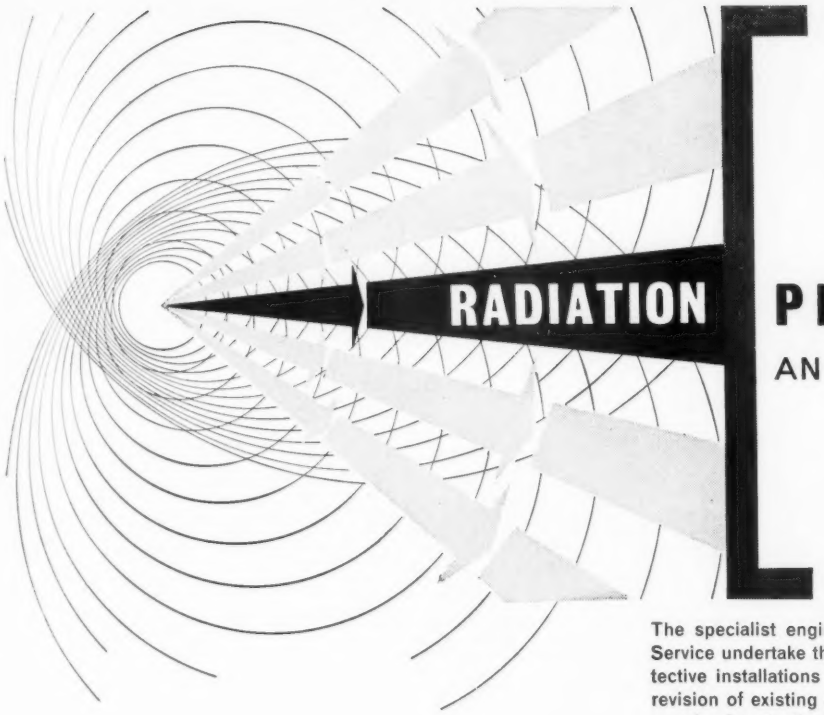
Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy. Her Majesty's Stationery Office, 1958

Vol. 11 Reactor safety and control 550 pp £5 11s

Vol. 18 Waste treatment and environmental aspects of atomic energy 624 pp £5 18s

A wide range of topics is covered under the general title of Volume 11. The first part includes legal and organizational aspects of safety, design of containment, safety devices, and hazards associated with various types of reactor incident. In the second part are papers on analysis of reactor kinetics from both theoretical and experimental standpoints, some valuable work on the behaviour of BWR's, and a series of papers on instrumentation and control rods.

In Volume 18 there are accounts from several countries on effective measures for processing radioactive wastes, effluents, off-gases etc., including recovery of valuable materials. Accidental release of radioactivity is discussed and there are papers giving bases for predicting hazards and appropriate protecting measures.



PROTECTION

AN ADVISORY SERVICE

The specialist engineers of R.C.I.'s Radiation Protection Service undertake the design and construction of new protective installations for both Gamma and X-rays, and the revision of existing protective measures, in addition to the supply of protective materials.

Barium concrete blocks · Lead ply panels · Lead lined sliding doors · Lead glass windows · Mobile screens for open site work · Lead containers for isotope storage.

X-ray equipment and protection for all industries.

(RCL0400)

RESEARCH & CONTROL INSTRUMENTS LTD.

Instrument House, 207 King's Cross Road, London, W.C.1

Illustrated is the twin cylinder model having a free air delivery of 50 c.f.m.

W&J

OIL FREE COMPRESSORS

DISPLACEMENT RANGE 1 to 136 c.f.m.

In the Food Processing, Brewing, Chemical and Paper Industries, also for pneumatic instrument control, it is essential that the air is free from oil in both droplet or vapour form. The W&J compressors use carbon rings and completely dry cylinders to achieve this purpose.

Manufactured now for several years they have proved themselves successful in many industries.

For further details please write requesting Leaflet Nos. 4, 20, and 28.

WILLIAMS & JAMES (ENGINEERS) LIMITED

GLOUCESTER · ENGLAND

TELEPHONE: GLOUCESTER 24021-2-3 · TELEGRAMS & CABLES: "COMPRESSOR GLOUCESTER"

Tick **No 88** on reply card for further details

Tick **No 89** on reply card for further details

For the most comprehensive stock available

BRASS, COPPER, PHOSPHOR BRONZE, GUN METAL, NICKEL SILVER
ALUMINIUM, DURALUMIN, TIN PLATES, ZINC SHEETS
TEE RODS, TUBES, STRIPS, SHEETS, BLANKS, ANGLES, CHANNELS
RIVETS, SCREWS, NUTS, WASHERS, GAUZE, SOLDER
PERFORATED SHEETS, STUDDING

J. SMITH & SONS (CLERKENWELL) LTD.
42/54, ST. JOHN'S SQUARE, CLERKENWELL, LONDON, E.C.1

phone: CLE 1277 (14 lines)
Screw Dept: CLE 0925

NUCLEAR REACTOR PHYSICS

an elementary course

by JAMES F. HILL B.Sc. principal, Reactor School A.E.R.E. Harwell

In response to widespread demands, we have reprinted the course in basic reactor physics which was specially written for NUCLEAR POWER and published in serial form during 1956 and 1957. The monograph has been revised by the author and forms an excellent introduction. (64 pp. in stiff boards.)
Price: UK, 30s + 1s 3d Abroad $5 + 20c or equivalent

TO: ROWSE MUIR PUBLICATIONS LTD
3 PERCY ST, LONDON W 1.

Please send me____ copy/s of Hill's REACTOR PHYSICS

☐ I enclose_____

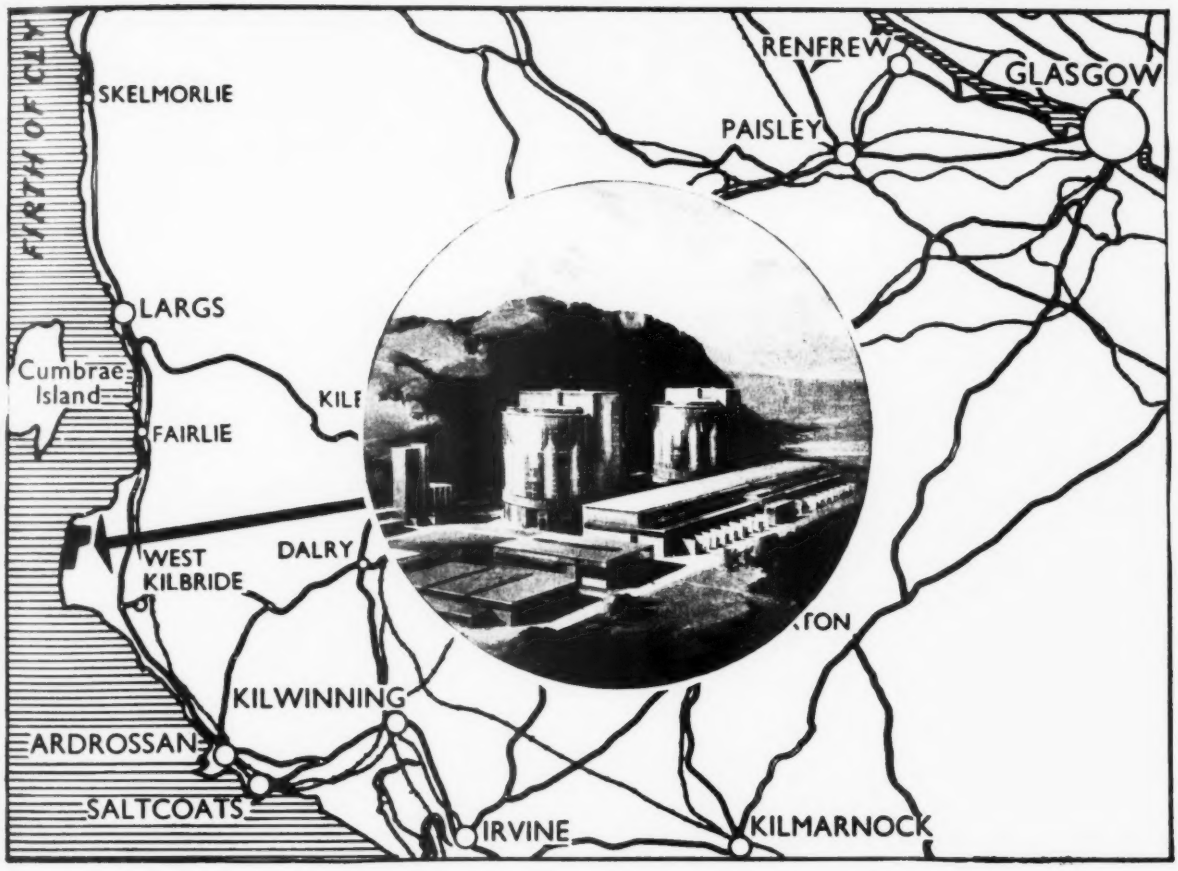
☐ Please invoice me

NAME_____

ADDRESS_____

Tick **No 205** on reply card for further details

The Power of the Atom



at Hunterston

Simon-Carves are responsible for nearly half the contract value of the South of Scotland Electricity Board's nuclear power station at Hunterston. This responsibility embraces design and supervision of all civil engineering construction works, including biological shieldings and their cooling systems, all steel structures and building superstructures, the condenser circulating water system and water treatment plants, and the sixteen steam-raising units and auxiliary equipment associated with the two nuclear reactors. At the same time the Simon-Carves research organisation and the international experience of Simon-Carves in heavy engineering design and large-scale contracting are being applied, in association with The General Electric Co Ltd of England, to the development of even more advanced nuclear power stations in Great Britain and throughout the world.

Simon-Carves Ltd

SIMON ENGINEERING GROUP

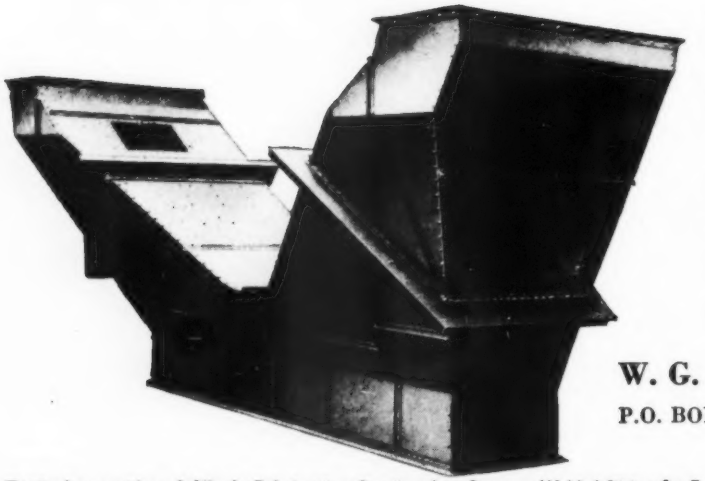
NUCLEAR POWER DIVISION | Cheadle Heath, Stockport

IN ASSOCIATION WITH THE GENERAL ELECTRIC CO LTD OF ENGLAND

Tick **No 90** on reply card for further details

Tick **No 91** on reply card for further details

Fabricated Platework to your specification



We specialise in welded or riveted fabrications in Mild Steel, Stainless Steel and Aluminium Alloys and pride ourselves on the attention paid to constructional details which ensure trouble-free service for the finished product.

A typical example of our craftsmanship is the fabrication of Ducts of rectangular design for Power Stations or Boiler Houses. They are accurately fabricated to suit your requirements.

Our "FABRICATED PLATEWORK" Brochure fully describes our Service and is available on application.

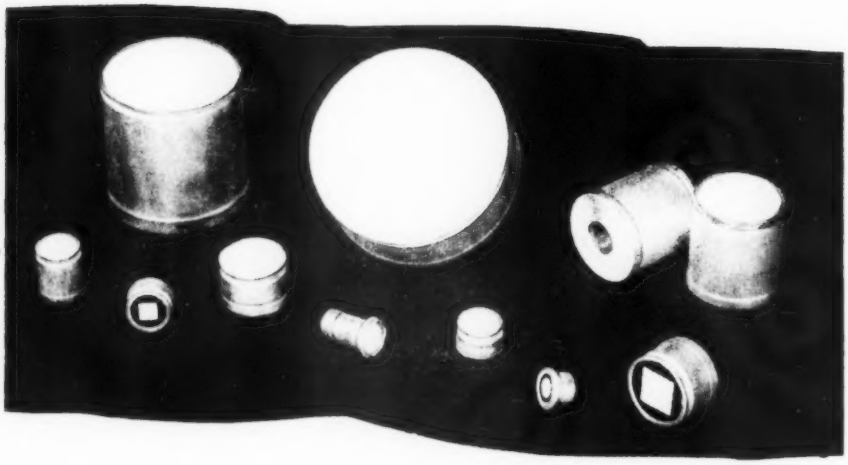
W. G. ALLEN & SONS (TIPTON) LTD.

P.O. BOX 4 · TIPTON · STAFFS

Tel: TIPTON 1266

Typical examples of Allen's Fabrication Service: *Low Pressure Welded Piping for Exhaust Steam, Gases, Water, etc. Pipes and Ducts for Super Power Station Boiler Plant; Hoppers; Casings; Tanks; Flat Platework; Manipulated Platework of all kinds; Bed Plates and Frames for Machines, etc.*

CRYSTAL PHOSPHORS



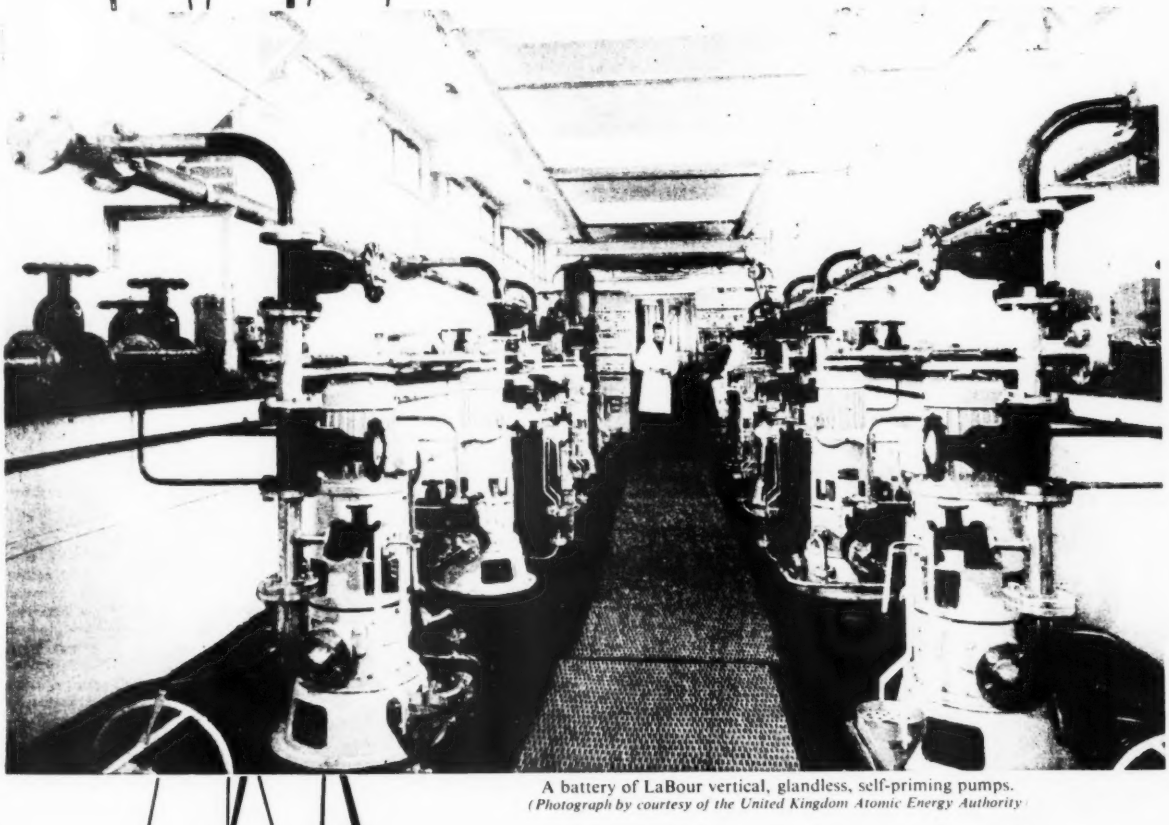
Hilger & Watts crystal phosphors are highly efficient in detecting and resolving X-rays and gamma-rays, and so are well suited for use in pulse-height analysers. We grow them from very pure melts of thallium-activated sodium iodide, and their potassium content is negligible.

We make a standard range of crystals, whose sizes range from ½ in. in diameter and ½ in. thick, to 4½ in. in diameter and 2 in. thick. The crystals are mounted in metal containers, which are lined with magnesium to increase their light output.

HILGER & WATTS

HILGER & WATTS LIMITED 98 ST PANCRAS WAY LONDON NW1 *Tel: GULliver 5636*

APPROVED BY
UNITED KINGDOM ATOMIC ENERGY AUTHORITY



A battery of LaBour vertical, glandless, self-priming pumps.
(Photograph by courtesy of the United Kingdom Atomic Energy Authority)

More than 250 LaBour pumps have been installed at one establishment alone of the U.K.A.E.A. Whether it is liquors or slurries, chemicals or effluents, mine dewatering etc., experienced engineers repeatedly specify LaBour pumps. They know that the simple, one-moving-part design assures uninterrupted service, long life and reduced maintenance. They appreciate the 'extra' features that LaBour pumps have—extra thick sections and extra heavy bearings which mean rigidity; the extra deep stuffing box; and the extra special materials which give extra resistance to corrosion and erosion.

LABOUR

BRITISH LABOUR PUMP CO. LTD. BLUNDELL ST. LONDON N7 TEL: NORTH 6601-5

P2320

Tick **No 93** on reply card for further details

Tick No 94 on reply card for further details

ROLLED STEEL RINGS

IN CARBON AND ALLOY STEELS

Leaflet giving full details of manufacturing capacity available on request

JOHN BAKER & BESSEMER LIMITED

Kilnhurst Steel Works G.P.O. Box No. 3
Rotherham Yorkshire Phone: Mexboro'
2154/7 & 3793 Telegrams: Tyres Mexboro'

London Office
Locomotive House, Buckingham Gate,
London S.W.1. Telephone: Victoria 5278/9

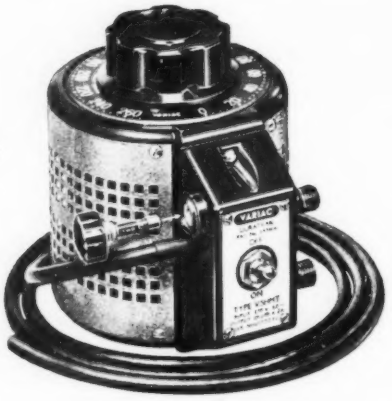
Variac with Duratrak*

for high-efficiency voltage control

VARIAC is the original continuously-adjustable auto-transformer, providing a smoothly variable output voltage from zero to 17% above line. Ultra-low-loss 'rolled' core and DURATRAK (patent) track surface give very high efficiency at all settings. A very wide range of models is available, from small units (e.g. type V-5, illustrated on right) for laboratory and instrument use to large ganged assemblies for three-phase power.

VARIACS can be supplied open or covered, as single units or ganged assemblies of two or more units, for manual operation or motor-driven. The range includes portable models, metalclad models, dual-output models, high-frequency types, and many 'specials'.

*DURATRAK is a rhodium-covered, silver-plated track surface, which inhibits oxidation of the brush track and greatly reduces contact resistance, giving longer life, increased overload and surge capacity and maximum economy in maintenance.



Type V-5HMTF, a small VARIAC for laboratory use. Output 0-270 V, continuously adjustable, from 230 V 50 c/s mains. Rated current 2 A. Provided with terminals, switch, fuse and 3-core lead.

For complete information on the entire VARIAC range, request **Catalogue 424-UK**

Only VARIAC has DURATRAK

Claude Lyons Ltd.

VARIAC and DURATRAK are registered trademarks DURATRAK is protected by U.K. patent No. 693406

76 OLD HALL ST LIVERPOOL 3 · Tel: CENTRAL 4641-2

VALLEY WORKS · HODDESDON · HERTS · Tel: HODDESDON

4541/4
CL/46/E2A

Tick No 95 on reply card for further details

By kind permission of the N.C.B. North Eastern Division

PROTECT WITH EVOKOTE

EPIKOTE RESIN BASED PAINTS

Above:—Ammonium Sulphate plant at Manvers Main Coking Plant, treated with Evokote Type 10
Below:—Maplewood floor treated with Evokote Type 20 at the works of John Mackintosh & Sons Ltd., Halifax

Four air drying grades supplied to combat all types of aggressive and corrosive conditions.

A PRODUCT OF EVODE OF STAFFORD

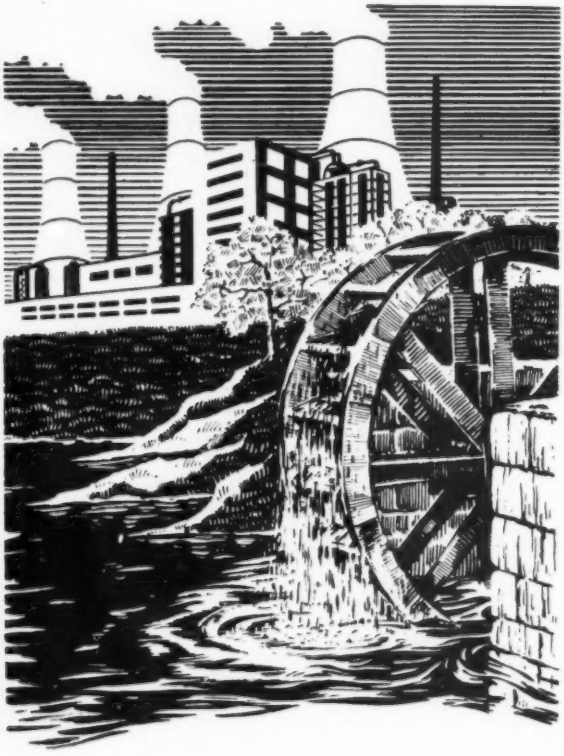
Manufacturers of BITUGEL, EVODYNE and EVO-LED paints

✳ **SEND FOR LITERATURE** EVODE LTD., (PAINTS DIVISION) STAFFORD. Telephone: 2241-5

London Office: 82 VICTORIA STREET, S.W.1. Telephone: ABBey 4622-3

M-W.115R

Tick **No 96** on reply card for further details



WATER

is still in the foreground...

However revolutionary the methods of producing power may become, water is still all-important; and the need to give complete and lasting internal protection to water tanks in modern plants remains paramount.

With a reputation consolidated over 30 years of successful use **BITOTES Solution and Enamel** prevents interior corrosion of all steel and concrete water containers and conduits. BITOTES cannot crack or peel and is tasteless and odourless when dry. It is fully approved for Fresh Water, Drinking Water, Demineralised Water, etc.

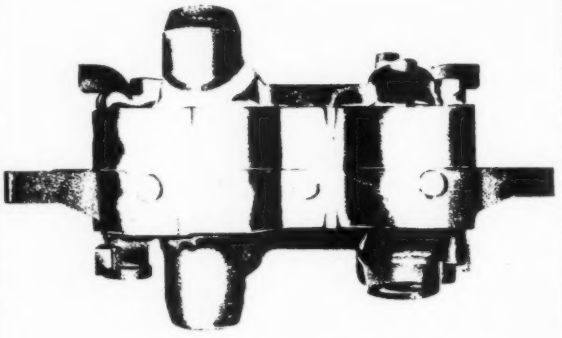
May we send you details

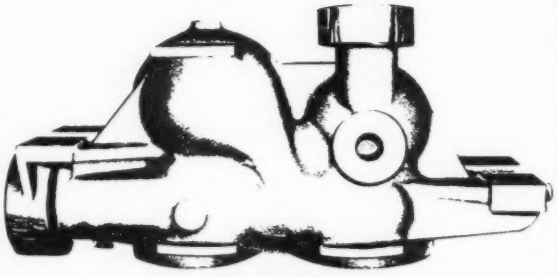
BITULAC LIMITED

(PAINTS DIVISION)

Collingwood Buildings, Newcastle upon Tyne, 1.

London Office: 189/190 Temple Chambers, Temple Avenue, London, E.C.4





ATLAS

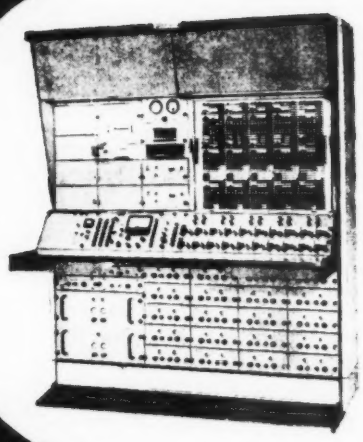
STEEL CASTINGS

FOR INTERNAL PRESSURE WORK

Turbine Casings, Steam Chests, Valves, etc., in carbon and alloy steels up to 15 tons weight and to any specification on ADMIRALTY, WAR OFFICE, LLOYD'S and other LISTS

THE ATLAS STEEL FOUNDRY & ENGINEERING CO. LTD.

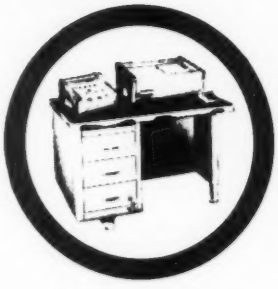
Atlas Steel Works: Armadale, West Lothian, Scotland
Telegrams: "Atlas Armadale, West Lothian"
Telephone: 323 Armadale



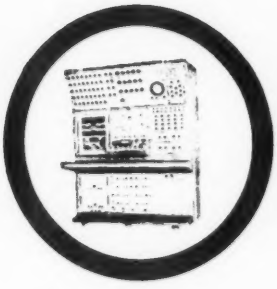
The new 231 R Computer can hold up to 100 amplifiers and other related non-linear equipment. New removable patch panel greatly speeds programming. Optional items include digital potentiometers and ADIOS (automatic digital input-output system)

NEW "PACE" ANALOG COMPUTER 231 R...

... with highest precision : 0,01 o/o

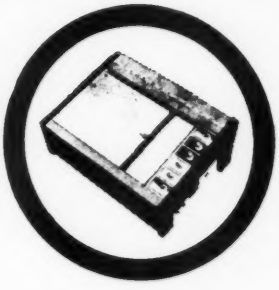


Dataplotter 1133 A.



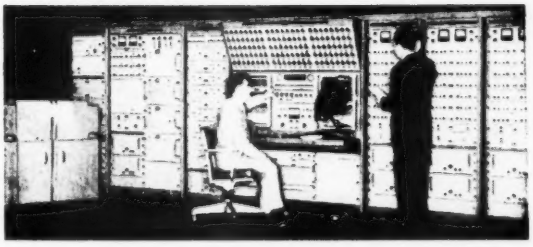
131 R Analog Computer

Eight Channel Rectilinear Recorder 1902-D.



Variplotter 1100-D.

Electronic Associates, Inc. has been the world's leading producer of Analog Computers and Plotting Equipment or over 5 years. For further information on their PACE Equipment the European Sales Office and Computation Center at Brussels is ready to assist European Industry



Rental facilities at European Computation Center in Brussels. Electronic Associates Application engineers are available to assist clients with their problems.

PRODUCERS OF "PACE" ANALOG COMPUTERS

ELECTRONIC ASSOCIATES, INC.

EUROPEAN SALES OFFICE AND COMPUTATION CENTER

43, rue de la Science - Brussels - Belgium - Tel. 11.43.69

An A.E.I Company

Tick **No 99** on reply card for further details

Tick No 100 on reply card for further details

HAVE YOU BEARING PROBLEMS?

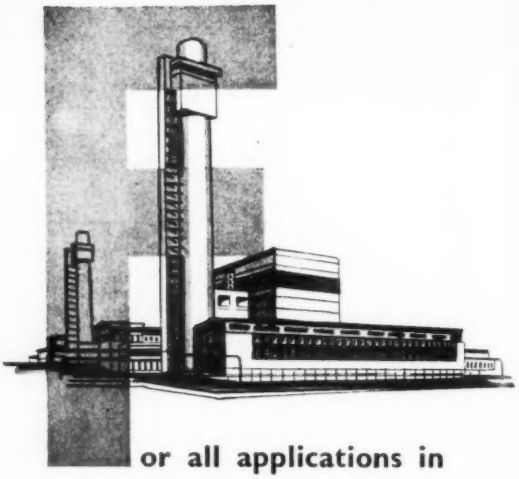
. . . you have —then let us shoulder them for you

Problems are arising every day in every field of engineering, especially for the bearing user. For example, two major fields of operation, atomic energy and gas turbines ; speeds, loads, or ambient temperatures are likely to be high ; whilst special lubricants and special provisions for lubrication are often required. We have an extensive technical and development section which are constantly improving and developing new designs in bearing application.

HOFFMANN BALL & ROLLER BEARINGS

THE HOFFMANN MFG. CO. LTD., CHELMSFORD, ESSEX

Tick No 101 on reply card for further details



or all applications in Nuclear Power plants . . . . . continue to fit

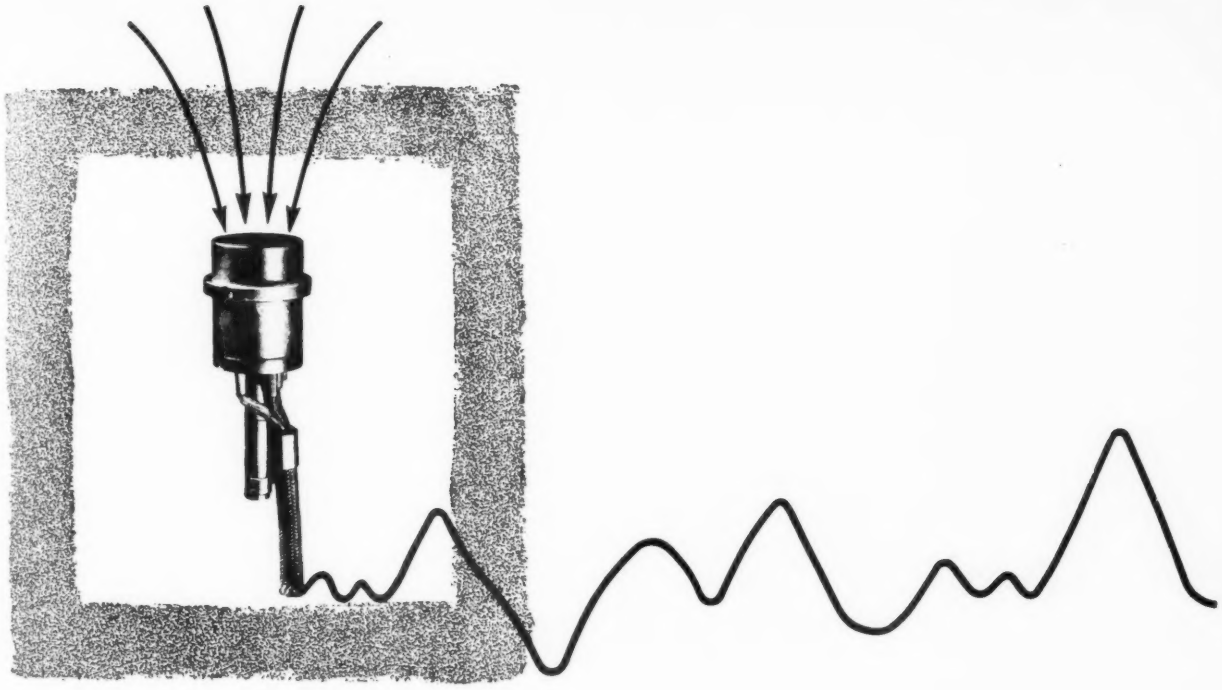
FREMO STAINLESS STEEL

bolts, nuts, screws and other fasteners with corrosion, contamination and heat resistant properties.

FREMO TRADE MARK

FREDERICK MOUNTFORD (BIRMINGHAM) LIMITED

Fremo Works, Moseley St., Birmingham, 5
Tel. MIDland 7984 PBX
Grams 'FREMO' Birmingham



precision in pressure measurement

NOW AVAILABLE—
GENERAL-PURPOSE PRESSURE TRANSDUCER—TYPE NT. 4-313

FLUSH DIAPHRAGM
STAINLESS STEEL CASE
MINIATURIZED—5/8″ DIAMETER
LINEARITY & HYSTERESIS 0.75%
INSENSITIVE TO ENVIRONMENT
INDIVIDUALLY CALIBRATED

BRIEF SPECIFICATION

OUTPUT:	Nominal 20 mV at 5V, DC or AC r.m.s. (0-20 Kc/s) excitation.
STANDARD PRESSURE RANGES:	0-100 p.s.i. to 0-5,000 p.s.i. gauge or absolute. Lower and higher ranges available on special order.
COMPENSATED RANGE:	Temperature compensated —65 F. (— 55 C.) to + 250 F. (+ 110 C.)
ZERO SHIFT:	Not greater than 0.01% full output per °F.
LINEARITY & HYSTERESIS:	Less than 0.75% full output up to 2,500 p.s.i.g. ± 1.0% full output above 2,500 p.s.i.g.
DIMENSIONS:	$\frac{5}{8}$″ (15 mm) nominal diameter, 1″ (26 mm) nominal length.

Manufactured under exclusive licence from C.E.C., CALIF., U.S.A.

Write now for details of this new range of Solartron Transducers

SOLARTRON

THE SOLARTRON ELECTRONIC GROUP LTD.,
Transducer Division, Thames Ditton, Surrey
Tel: EMBerbrook 5522 Cables: SOLARTRON, Thames Ditton
International Telex: 23842 Solartron T.Dit.

Tick **No 102** on reply card for further details

Tick **No 103** on reply card for further details

PURE TUNGSTEN FABRICATED BY MUREX

The above illustration shows a selective range of pure tungsten articles fabricated by machining or spinning. We shall be pleased to quote against customers drawings.

MUREX LIMITED *(Powder Metallurgy Division)*
RAINHAM • ESSEX *Telephone: Rainham, Essex 3322.*
Telex 28632. Telegrams: Murex, Rainham-Dagenham Telex
LONDON SALES OFFICE: CENTRAL HOUSE UPPER WOBURN PLACE, W.C.I.

industries atomiques

International review for the peaceful application of nuclear energy

INDUSTRIES ATOMIQUES
is the only international technical and industrial review printed in French, which specialises entirely in nuclear and related subjects.

INDUSTRIES ATOMIQUES is read by industrialists, engineers, technicians and chemists, heads of technical firms and by all those engaged in the world of science. In short, it is intended expressly for all specialists interested in research and in its practical realisation.

In view of its international character, **INDUSTRIES ATOMIQUES** is read and appreciated in countries all over the world.

Up to date, more than 200 authors, all specialists, have honoured this review with their collaboration, and have contributed **previously unpublished** articles of high scientific value, abundantly illustrated.

INDUSTRIES ATOMIQUES is a source of precise documentation, constantly being brought up to date. The international information and the list of suppliers to the atomic industries printed in its pages will be found invaluable.

Annual Subscription

12 numbers per year

French francs	4,150
Belgian francs	510
Swiss francs	35
U.S. dollars	8.50
Pounds sterling	3

Industries Atomiques Subscription form

Subscriptions can be paid in the currency of the country at any European post office.

We desire _____ annual subscriptions, starting from _____, to be sent to (surname, Christian names, or firm's name, and address) _____

Method of payment _____ Date and signature:

(This form should be returned in a stamped and addressed envelope to NUCLEAR POWER, 3 Percy Street, London, W1.)

Tick **No 104** on reply card for further details

CAST IRON VESSELS

for the

ATOMIC ENERGY AUTHORITY

Approved by Lloyds for Class II welding for pressure vessels

One of the battery of special Cast Iron Vessels supplied to the U.K. Atomic Energy Authority. The body of the vessel is approximately 5ft. 8in. outside diameter by 6ft. 3in. high and the complete vessel weighs approximately 30 tons.

WIDNES

ESTABLISHED 1841

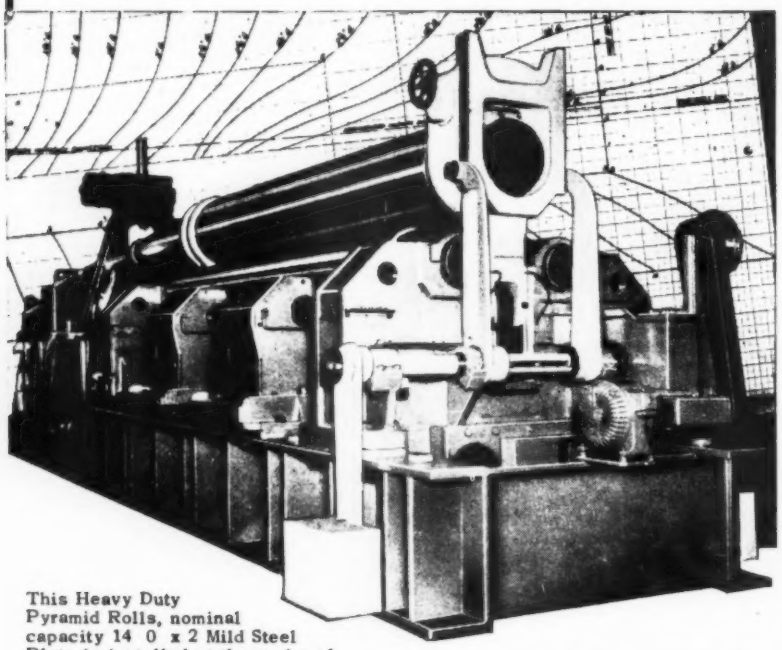
FOUNDRY & ENGINEERING CO. LTD.

LUGSDALE ROAD, WIDNES, LANCS. TEL. 2251/4. GRAMS. 'FOUNDRY WIDNES'

W 40

 Tick **No 105** on reply card for further details

Chart-Checked PLATE ROLLING



This Heavy Duty Pyramid Rolls, nominal capacity 14 0 x 2 Mild Steel Plate is installed at the works of Messrs. Edwin Danks & Co. (Oldbury) Ltd.

for accurate estimating and exact operation

BRONX Plate Bending Rolls are supplied with a capacity chart from which you can readily determine the complete range of widths and thicknesses and minimum diameters the machine will roll.

A wide range of massively built Bronx Plate Bending Rolls give consistent accuracy with thinnest to thickest steel plates up to 25 ft. in width, and standard machines cope perfectly with conical work. Catalogue on request.

Telephone: LYE 2307 & 2308

BRONX ENGINEERING CO. LYE, WORCESTERSHIRE

BRONX

PLATE BENDING ROLLS

Thermal
REFRACTORY CEMENTS AND POWDERS

We also manufacture an extensive range of Vitreosil Industrial Ware

Thermal Fused Alumina and Fused Magnesia Refractory and Insulating Cements are very simple to apply; water is the only additive necessary for mixing before application.

For base metal windings our C60 cement is ideal: for platinum windings our CC60 cement should be used. Molybdenum windings necessitate a silica-free cement, and our No. 101 cement is specially prepared for this purpose.

In addition, we have available Special Air-Setting Insulating Cements, which remain rock-hard up to 500°C.

Details of these special high temperature cements, and also of Thermal Fused Alumina and Fused Magnesia Powders will gladly be supplied on request.

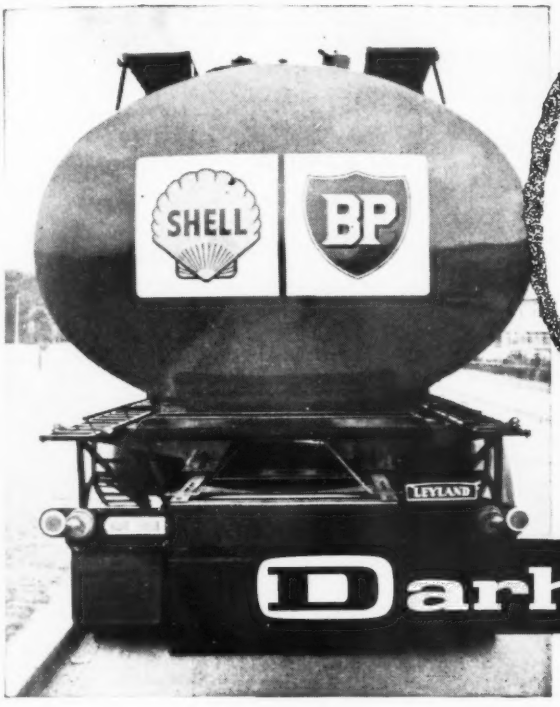
TSL

THE THERMAL SYNDICATE LTD.

P.O. Box No. 6, Wallsend, Northumberland. Telephone: Wallsend 6-3242

LONDON OFFICE:
12-14 OLD PYE STREET, WESTMINSTER, S.W.1. TELEPHONE: ABBEY 5469

With an end in view...



...about tanks

When industry enquires about the supply of road tanks, transportable tanks and storage tanks, more often than not they enquire of Darham.

Technical Advisory Service
Darham are known for the dependability in constructing tanks for the transporting or storage of liquids and powders. Much of the success of a Darham tank can be attributed to the Technical Advisory Service of Designers and Engineers, who study every individual requirement.

Solving the Problems
They apply their knowledge and skill to the problems of achieving the maximum payload possible, capacity, weight distribution, types of lining, insulation, loading and discharging techniques. The result? The finest tank that man can conceive.

DARHAM build fine tanks in Mild Steel (suitably lined if necessary), Stainless Steel and Aluminium.

JOHN THOMPSON GROUP

Darham

DARHAM INDUSTRIES (LONDON) LIMITED
17 Surrey St., The Strand, London, W.C.1
COVent Garden 0556
WORKS: BASILDON, ESSEX AND DURHAM CITY

MAKE LIFE EASIER with the PRICED STAINLESS STEEL STOCK LIST

Look first at the largest and most comprehensive Stock List in the Country. Mill prices and foot lbs. weights are shown against every item. The stock list is revised and mailed every sixty days. Write or phone for your copy today.

ANY QUANTITY AT MILL PRICES.
AID-ARB approved.

TAYLOR STAINLESS METALS LTD.

BRITAIN'S PRINCIPAL STAINLESS STEEL STOCKHOLDERS.
BUCKINGHAM AVENUE · SLOUGH · BUCKS · TEL: SLOUGH 24551
and at UNION CHAMBERS, 63 TEMPLE ROW, BIRMINGHAM 2 TEL: Midland 1430

Tick **No 109** on reply card for further details

Tick **No 110** on reply card for further details

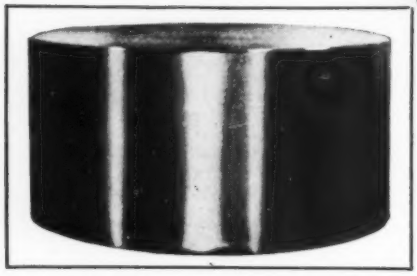
G.E.C.

HEAVY ALLOY

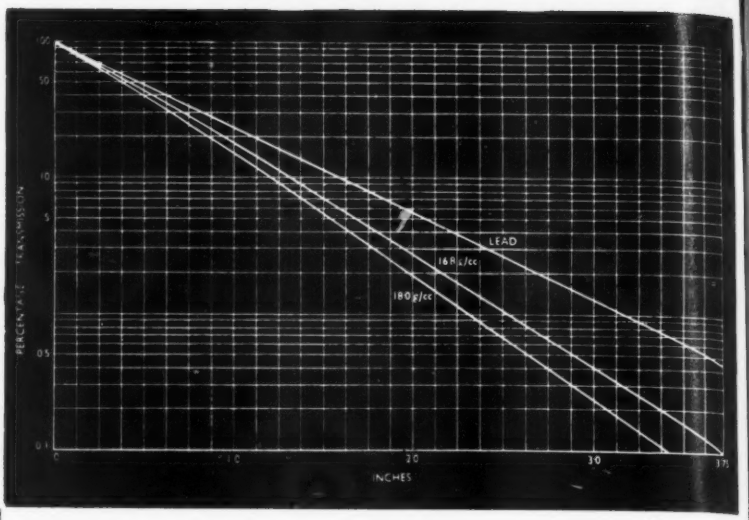
supplied in densities

16.8,17.0,17.5,18.0g/cc(nominal)

- ***for screening purposes***
- ***for balance weights***



The above piece of G.E.C. Heavy Alloy was made for the United Kingdom Atomic Energy Authority. It weighs 660 lb.



Broad beam absorption of Gamma-radiation from COBALT-60. Density: 16·8 g/cc. and 18·0 g/cc.

THE GENERAL ELECTRIC CO. LTD., Component Sales Dept., Osram Metals, East Lane, Wembley, Middlesex. Arnold 4321

'HYDROBORD'

for

NEUTRON SHIELDING

HYDROBORD provides insulation against Fast and Thermal Neutrons or combinations of both.

William Mallinson and Sons Ltd.

130 HACKNEY ROAD · LONDON · E.2

Telephone: Shoreditch 7654

Telegrams: 'Almoner', London

Lydney

BRITISH MADE PLYWOOD

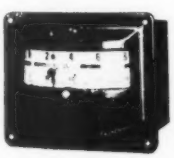
Tick **No 111** on reply card for further details

Tick No 112 on reply card for further details

Production British, Service International

West Instruments Ltd. provide a range of temperature controllers, produced in Britain for international markets in the plastics, metal, nuclear, ceramic, chemical and process industries. An efficient after-sales service is backed by speedy supply of spare parts by West representatives in major cities throughout the world. In this way West instruments, fitted to exported machinery, are assured efficient maintenance.

West instruments are proving themselves invaluable in countries as far apart as Holland and Hong Kong, India and Italy, New Zealand and Norway, South Africa and Sweden. Full details of equipment and services from:



WEST *Instrument* **LIMITED**

52 Regent Street,
Brighton, Sussex. Telephone: 28106

Associate of the West Instrument Corporation of Chicago U.S.A.

Tick No 113 on reply card for further details

IF process plant in stainless or alloy steels is your problem, our technical representative will be pleased to discuss it with you. Ring the people who spend their working life (and a great deal of their private life) thinking and planning in STAINLESS STEEL.

BURNETT & ROLFE LTD.

THE ESPLANADE, ROCHESTER, KENT
TEL: CHATHAM 41766

NORTHERN OFFICE: 32 DEANSGATE, MANCHESTER
TEL: BLACKFRIARS 9084

Tick **No 114** on reply card for further details

WHERE ONLY THE BEST IS GOOD ENOUGH

UKAEA
BRADWELL
BERKELEY
HUNTERSTON
HINKLEY POINT
MARCOULE
A. S. E. A. (SWEDEN)
AGIP NUCLEARE (ITALY)
CERN (SWITZERLAND)
DANISH A.E.C.

NUCLEAR INSTRUMENTATION

BY

"GR"

IS

THE EQUIPMENT OF CHOICE

NUCLEAR INSTRUMENTATION OF ALL TYPES

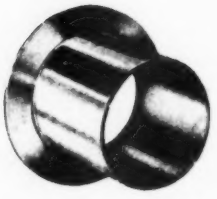
GENERAL RADIOLOGICAL LTD.
Nuclear Engineering Division
15-18 CLIPSTONE STREET, LONDON, W.1

REMOTE HANDLING AND SHIELDING

ENGINEERS!!
buy from
KIRKS-

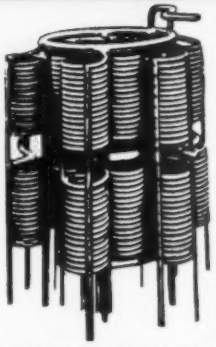
FORGED STEEL & STAINLESS STEEL FLANGES

TO BRITISH AND AMERICAN STANDARDS



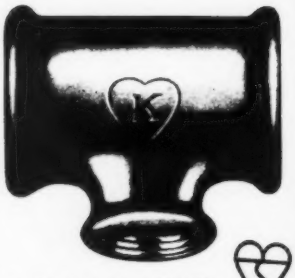
STAINLESS STEEL STUB NIPPLES AND OTHER PRODUCTS

FABRICATED PIPEWORK IN STEEL, STAINLESS STEEL AND COPPER



K

THE HEART OF RELIABILITY



MALLEABLE TUBE FITTINGS TO BRITISH STANDARD 1256

...and you **BUY BRITISH!**

KIRK

& CO (TUBES) LTD

74/82 PARADISE ST., LONDON, S.E.16
BERMONDSEY 3156/7/8
WALSALL · MANCHESTER · PONTYCLUN

– as British as the Flag

Tick **No 115** on reply card for further details

SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER.

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER.

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER.

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на карточке на противоположной стороне и отправьте в NUCLEAR POWER.

讀者詢問服務

在廣告上以有限的地方來解釋一些專门技術 及它們的効果 的確是有受限制的困难 若讀者欲要知道一些詳細的情形就請將对應的表格 取一張下來將閣下有疑问的項目 问号一下郵寄給子能工社免即可.

読者サービス

廣告紙面の関係上、製品の技術的細目は掲載しきれませんので詳しくは裏のカードの適當なナンバーに印をつけて原子力 兒社宛にて下さればお答へします.

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE № 17516

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Tech. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE № 17516

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Tech. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

SUBSRCIPTION CARD № 17516

YES!

I want my own PERSONAL copy!

Please send me NUCLEAR POWER for 12 months/until countermanded:

U.K. **£2. 2s. 0d.**

U.S.A. and Canada **$8.00 + 50c.** postage

Other countries **£3. 3s. 0d.**

☐ Subscription enclosed

starting with the _____ issue

☐ Invoice me later

NAME _____

SEND TO MY HOME/BUSINESS ADDRESS _____

_____

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

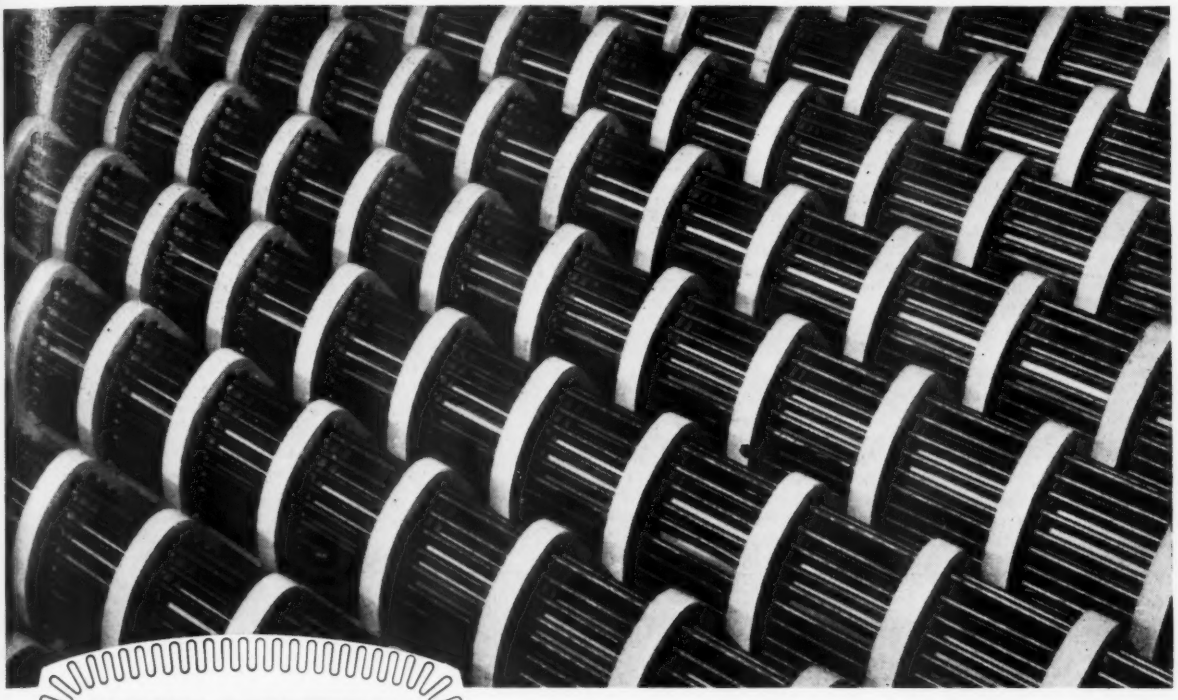
Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

A

AU
AU

N



METALECTRIC

our custom-built radiant and immersion elements can solve your nuclear engineering thermal problem.

METALECTRIC FURNACES LTD · SMETHWICK · ENGLAND

11/25/58

AUTO-KLEAN

FILTERS ANYTHING THAT FLOWS

AUTO-KLEAN
Self-cleaning plate-type filters for all liquids handling flows up to 150,000 gallons per hour and providing positive defined mesh filtration with additional magnetic protection.

AUTO-KLEAN CIRCO
Self-cleaning strainers for water circulating systems handling flows up to 180,000 gallons per hour.

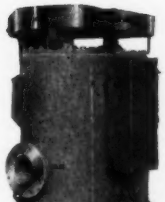
AUTO-KLEAN KOTON
Filters designed for depth filtration to defined micronic limits for all low viscosity liquids at flows up to 5,000 gallons per hour.

AUTO-KLEAN WYMESH
Special gauze filters for fine mesh protection at flows up to 42,000 gallons per hour.

AUTO-KLEAN LOLOS
Wire-wound filters for the protection of hydraulic systems at pressures up to 5,000 lbs. per square inch.

AUTO-KLEAN MICOM
Combined self-cleaning plate-type filter and paper filter giving both defined mesh and micronic protection for lubricating oil systems at flows up to 6,700 gallons per hour.

AUTO-KLEAN FLUSHFLO
Self-cleaning wire-wound filters for fully automatic protection of water and oil circulating systems at flows at up to 400,000 gallons per hour.

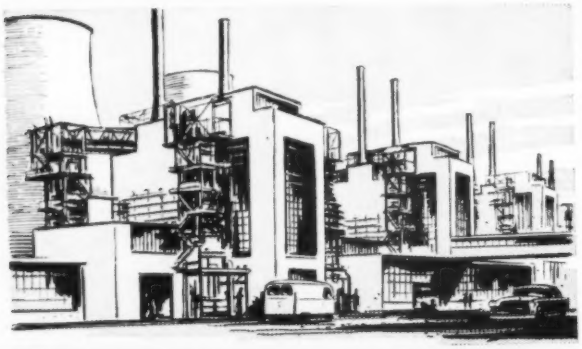


AUTO-KLEAN

AUTO-KLEAN MICOM · AUTO-KLEAN FLUSHFLO · AUTO-KLEAN CIRCO
AUTO-KLEAN LOLOS · AUTO-KLEAN KOTON · AUTO-KLEAN WYMESH

AUTO-KLEAN STRAINERS LIMITED
ENGINEERS IN FILTRATION
LASCAR WORKS · HOUNSLOW · MIDDLESEX
Telephone: HOUnslow 7722 (10 lines)

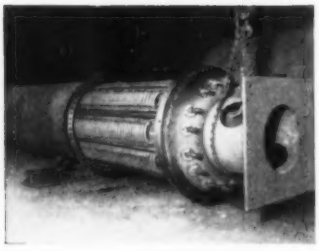
Tick **No 117** on reply card for further details



To be sure...

Since 1750 GRAZEBROOK have served Industry and have been in the forefront of Industrial development. Today the company is equipped to meet the most exacting demands of modern industry and we invite you to contact us with YOUR particular production problems.

GRAZEBROOK



LEAD SHIELDING

REACTOR TANKS

PRESSURE VESSELS
(STAINLESS STEEL AND ALUMINIUM)

CHEMICAL VESSELS • CALANDRIAS

can make it!

HEAVY MACHINING FACILITIES

Plant and Machinery manufactured to customers' design, including the Chemical, Steel, Plastic and Rubber Industries.

GREY IRON CASTINGS UP TO 20 TONS

M. & W. GRAZEBROOK LTD
HEAVY ENGINEERS & IRON FOUNDERS
DUDLEY - WORCS
Telephone: DUDLEY 5243I *Telegrams: Grazebrook, Dudley*

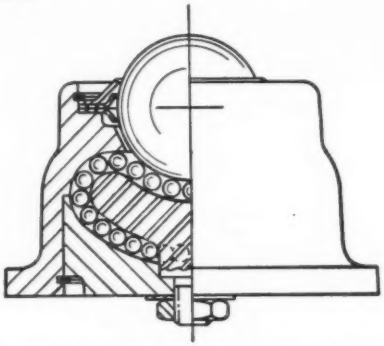
Make Light of Weight
with

AUTOSET

O.T.'s

World Patents Pending.

Omni-track Conveyor Ball Units having dynamic load capacities from 50 lb. to 5 tons each with ½" to 2" dia. load balls.



O.T.'s provide instantaneous change of direction automatically accommodated at any angle, with effortless ease. On cast iron or hardened steel plate starting effort may be as low as 1% of the gross load. Special rotary applications as low as 0·25% per gross load.
Ask for List No. 275/OT

CASTORS

Ask for List No. 275/C

Over 20,000 types and sizes including wheels from 2" to 46" dia. and loads up to 30 tons each. Sprung, automatically braked, Ackerman steered, Jacked, direction or wheel-locking, etc.

Twin 46" Pneumatics, 6-ton

6" tubular shank, 90-lb.

Twin 20" solid tyred, 5-ton

DRAWER SLIDES

Ask for List No. 275/S

Three-piece Extension Drawer Slides, 12" to 37" lengths

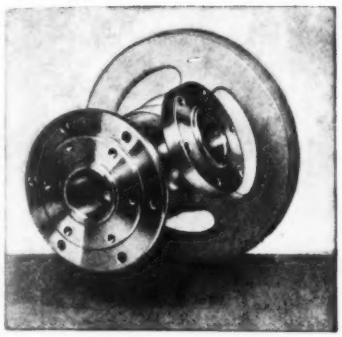
Two-piece Extension Drawer Slides, 10" to 25" lengths

Also Trolleys, Trucks, Conveyor Rollers, etc., etc.

AUTOSET (PRODUCTION) LTD.
73-78 STOUR STREET, BIRMINGHAM 18
Telephone : EDGBASTON 1143

Tick **No 120** on reply card for further details

Ultra High Vacuum for . . .



A 1 in. bore stainless steel right-angle shut-off valve containing no organic sealing material and capable of being baked at temperatures up to 500°C. The connecting flanges have special metal gasket seals terminating in either 1 in. diameter hard glass tube or stainless steel tube.

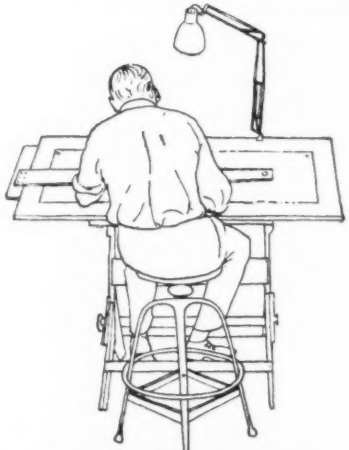
*1torr = MM Hg (B.S. 2951: 1958)

★ GAS DISCHARGE MACHINES
★ HIGH FIELD INTENSITY ACCELERATORS
★ CONTROLLED THERMO-NUCLEAR REACTIONS
★ THE STUDY OF VERY PURE THIN FILMS
★ SURFACE PHENOMENA
★ EMISSION CHARACTERISTICS

Many of these applications need a vacuum in the region of 10^{-10}* which necessitates the use of bakeable metal systems. A large or small "Speedivac" pumping station can be supplied for this purpose, each unit works tested to ensure ultra high vacuum performance and constructed from individually tested components including

- ★ **Bakeable Low Pressure Ionisation Gauge and Pump**
- ★ **All-metal Bakeable Cut-off Valves**
- ★ **Mercury or Fractionating Oil Diffusion Pumps with Stainless Steel Liquid Air Traps**
- ★ **Bakeable Metal Gasket Seals between Pumps, Traps and System**

EDWARDS HIGH VACUUM LTD · MANOR ROYAL · CRAWLEY · SUSSEX · ENGLAND
Crawley 1500



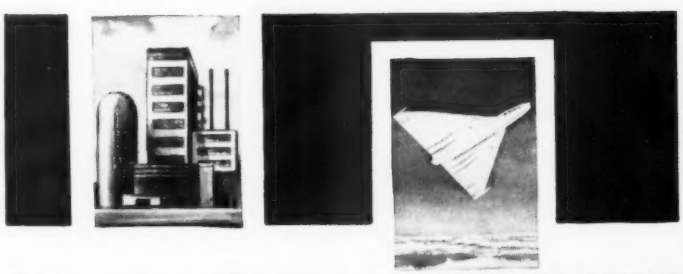
the embodiment of this scientific age

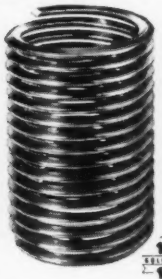
Forward-looking engineers are embodying Heli-Coil Screw Thread Inserts in their designs because competition demands that they use only today's most advanced and successful techniques.

The Heli-Coil method of screw thread engineering can improve products in almost an infinity of ways. It can make dramatic cuts in time and labour costs.

The Heli-Coil Insert is ideal for automation. Why not have all the information in front of you—ask for Sales Leaflet APL 48/E · 13

HELI-COIL*
SCREW THREAD INSERTS





Your newest design . . . is it quite up to date?

1909 GOLDEN JUBILEE 1959

*HELI-COIL is a registered trade mark

Write for more data on HELI-COIL inserts to **ARMSTRONG PATENTS CO. LTD. EASTGATE, BEVERLEY, YORKS.**

Tel: Beverley 82212 (6 lines)

Tick **No 121** on reply card for further details

Tick **No 122** on reply card for further details

LONDEX

STAINLESS STEEL

PRESSURE

SWITCHES

List available No. 119, 14 pages

Now for the first time a complete range of pressure switches for working with *corrosive* gases and liquids.
Ranges cover operating pressures from 5-1000 lbs. p.s.i.
All parts in contact with operating liquid or gas are manufactured from *stainless steel*.
These switches are of special interest to (control) engineers in Chemical and Nuclear establishments. Interest extends to food and other processing industries.
These switches are in addition to the large number of different types already made.

LONDEX LTD.

ANERLEY WORKS · LONDON · S.E.20
SYDENHAM 3111 (5 lines)

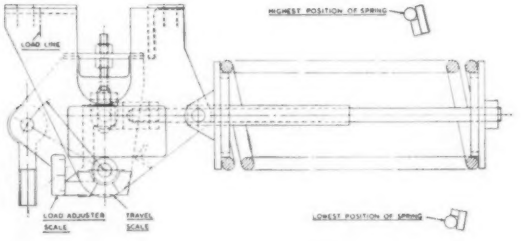
TA2104

Tick **No 123** on reply card for further details

NOW...

'M' range Gensprings up to 80,000 lbs. and 12″ travel ... only 2% deviation

Our new 'M' range of Constant Support Hangers is now available for loadings up to 80,000 lbs. and 12″ travel—down to 2% deviation. More economical, both in application and first cost, and more compact than previous types, they provide increased travel with less headroom requirement. The 'M' Hangers have been developed from the 'W' range which have been chosen for Britain's first three commercial nuclear power stations.



At Bradwell, Berkeley, and Hunterston, Gensprings will provide safe, secure support of vital piping installations. The Constant and Variable Gensprings, together with the Sway Brace, provide a fully comprehensive range for all pipe support requirements and are, of course, widely used in conventional power stations, oil refineries, chemical plants, etc.

If you would like to know more about the new 'M' range, please send for full details.

Vokes Genspring

SUSPENSION SYSTEMS

VOKES GENSPRING LTD · GUILDFORD · SURREY
VG/24

Tick **No 124** on reply card for further details

Tick **No 125** on reply card for further details

UNION CARBIDE TRADE MARK

RARER METALS...

Ce
Cr
Ga
Nb
La
Ta
V
Y

UNION CARBIDE can now supply a number of the rarer metals, many of which are available in a very high purity grade

...AND THEIR COMPOUNDS

Over 70 compounds of the rarer metals are available and include oxides, nitrides, borides, carbides, chlorides, phosphides, sulphides, phosphates, selenides, acetylacetonates and carbonyls.

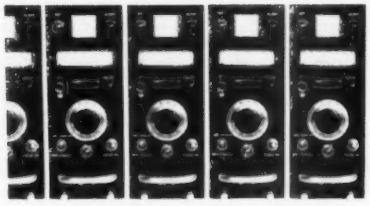
CATALOGUES OF DATA SHEETS

giving the composition and properties of the metals and compounds can be obtained on request.

UNION CARBIDE LTD. ALLOYS DIVISION
103 Mount Street, London W.1

The term 'Union Carbide' is a trade mark

murphy



TRIP AMPLIFIERS

for monitoring

TEMPERATURE, STRAIN,
and any low level d.c. signal.

Some salient features:

Transistorised high-speeed chopper amplifier.

Relays and lamps operate at alarm and trip levels.

Trip margin indication with two scales at 10:1 sensitivity ratio.

Lockable pre-set trip level control calibrated 0 — 1000.

Rejects extraneous 50 c.p.s pick-up.

Incorporates all possible fail-safe techniques.

Compact size, $8\frac{3}{4}'' \times 3\frac{1}{2}'' \times 13''$ *deep allows 5 units per standard 19" rack.*

For further information please contact:

MURPHY RADIO LTD (ELECTRONICS DIVISION)
WELWYN GARDEN CITY, HERTFORDSHIRE.
TEL. No. WELWYN GARDEN 3434.

GORDON

IGEMA DISTANCE BOILER WATER LEVEL INDICATOR

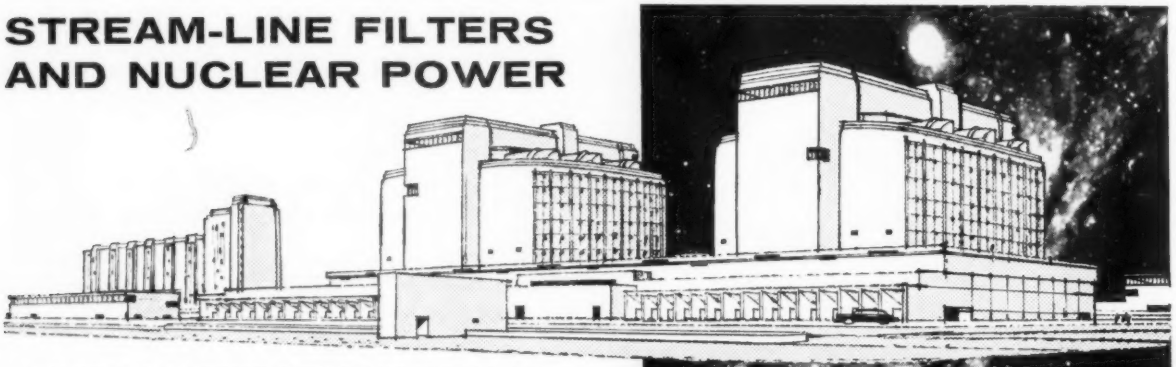
BRADWELL	*72*	*INDICATORS*
BERKELEY	*64*	*„*
HINCKLEY POINT	*24*	*„*
TOTAL	*160*	*FOR 3 POWER STATIONS*

Showing once again the complete confidence placed in the IGEMA INDICATOR for absolute ACCURACY and RELIABILITY in water level indication

JAMES GORDON & CO LTD, DALSTON GARDENS, STANMORE, MIDDX.

A MEMBER OF THE ELLIOTT-AUTOMATION GROUP

STREAM-LINE FILTERS AND NUCLEAR POWER



The security of oil-immersed circuit breakers or transformers depends on the condition of the oil. In Stream-Line filters the engineer has at his disposal equipment specially designed for the complete removal of contamination in insulating oil and which meets the most stringent requirements. That's why Stream-Line filters have been specified for Chapel Cross and Berkeley, and are in wide use throughout the U.K.A.E.A. A single passage through a Stream-Line filter ensures the elimination of solid impurities, even the finest colloidal carbon; dehydration, including the removal of dissolved water, and de-aeration, including the removal of dissolved gases. A dielectric strength far above that specified for the highest quality new oil is achieved by a standard Stream-Line filter. Our research and development department will be glad to answer your queries. Write for Catalogue W. 1031.

A WORD ABOUT HIGH VACUUM

Stream-Line filters designed to operate under high vacuum can be supplied. Details are available on request of models yielding remarkable performances. For most requirements the standard Stream-Line filter gives precisely the service demanded.

A fully mobile Stream-Line filter.

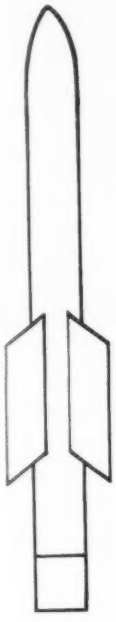
STREAM-LINE FILTERS

STREAM-LINE FILTERS LIMITED, HENLEY PARK, NORMANDY, NR. GUILDFORD, SURREY.

A member of the VOKES Group with world-wide representation. Telephone: Normandy 3211/3. Telegrams: Edgefilt, Guildford.

SF/29

Tick No 128 on reply card for further details

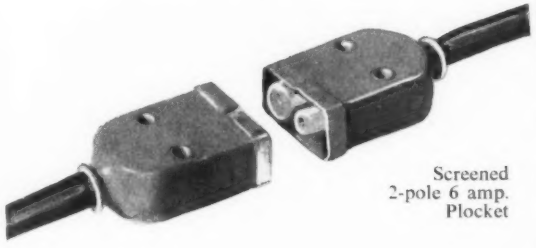


PLOCKETS for ROCKETS

Manufactured By

MB M LIMITED

Universally used and proved in the guided missile and aircraft fields as a quick release connector



Screened 2-pole 6 amp. Plocket

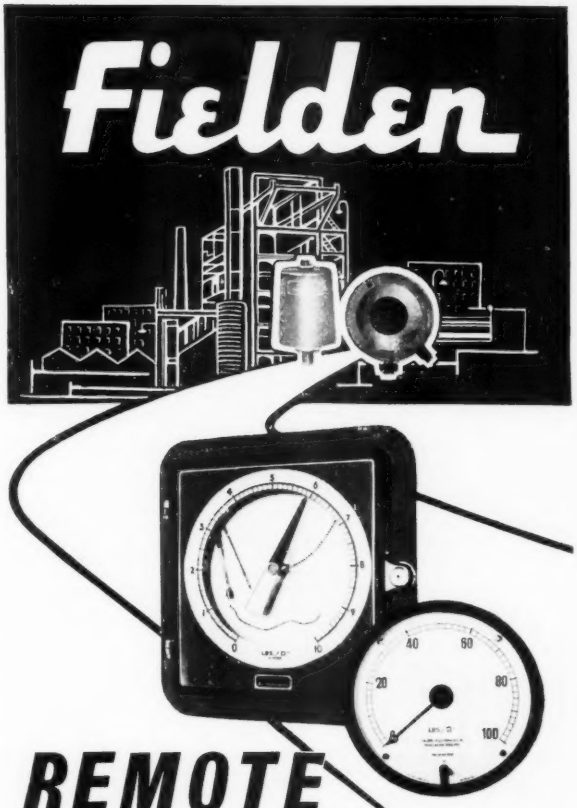
Unscreened 4-pole 6 amp. Plocket

Available in 1-pole, 2-pole, and 4-pole. Screened and unscreened, free and bulkhead fittings, etc.

For further details please write to

M.B. METALS LTD.
VALE WORKS
PORTSLADE SUSSEX
TELEPHONE NUMBER HOVE 48623

Tick No 129 on reply card for further details



REMOTE PRESSURE

INDICATING · RECORDING · CONTROLLING

FOR . . .

Steam and other gases.

Water, oil and other liquids.

Pressures down to 5″ wg and up to 15000 p.s.i.

Indicating, recording or controlling or any combination of these features.

Vacuum, absolute and differential pressures as well as the usual gauge pressures.

Transmission over distances of a few feet or hundreds of yards.

WITH . . .

Accuracies as high as 0·5%.

Immediate response at the receiving instrument to changes in pressure at the measuring point.

Robust but simple wiring between the transmitter and the indicating recording or controlling instrument.

Intrinsic safety certificate.

Wide range of indicating meters in many sizes, recorders for wall and panel mounting, controllers for electrical and pneumatic control etc.

★ *Write for Remote Pressure brochure* ***NP***

Fielden

FIELDEN ELECTRONICS LIMITED · WYTHENSHAWE · MANCHESTER
'Phone: Wythenshawe 3251 · 'Grams: Humidity Manchester
also AUSTRALIA, ITALY and CANADA.
Branch Offices: LONDON, WALSALL, STOCKTON-ON-TEES and EDINBURGH

Indicating Recording Control

Tick **No 130** on reply card for further details

Inside Story

ENDECOTTS TEST SIEVES

No Crevices to trap particles, frame and wire cloth are joined as one.

Guaranteed Accurate — Manufactured under licence from the British Standards Institution.

Mechanical Sieving is ideal with Endecotts Sieves—several simultaneous tests are possible with intermediate receiving pans.

British, U.S. Standards and Tyler Equivalents are readily available, many other international standards also supplied.

"ENDROCK" TEST SIEVE SHAKER

saves valuable time and effort of skilled personnel, similar to manual motion but is more consistent having a regular mechanical action—a time switch controls the length of time for tests.

We operate a **Recovering Service**—if sieving is important to your business, ring or write for literature —or for any advice you require—we'll be glad to help.

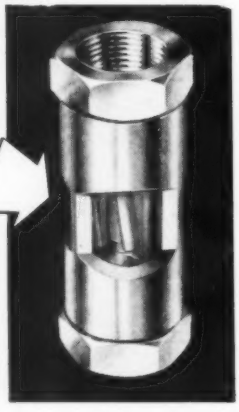
ENDECOTTS (FILTERS) LTD

Lombard Road · London, S.W.19

Telephone: LIBerty 8121/2 · Telegrams: ENDFILT, LONDON

Tick **No 131** on reply card for further details

See the flow with the 'Telicator'



Both low and high pressure systems can be fitted with a Telicator Visual Flow Indicator, which is a simple instrument for indicating the flow, whatever the viscosity. The rotors are specially designed by Dukes and Briggs to give the clearest indications over specific ranges of flow rate. Water supplies for cooling purposes and forced lubrication systems are two typical applications. A new model is under development for use with opaque fluids, and special designs can be made to meet specific requirements.

Note these features

- *Simple design ensures complete reliability.*
- *Extreme sensitivity at all pressures.*
- *Units readily adaptable to existing installations.*
- *May be mounted in any plane.*
- *Comparative flow gauged by speed of revolving rotor.*

Bailey's REGD.

SIR W. H. BAILEY & COMPANY · LIMITED
PATRICROFT · MANCHESTER · ENGLAND

Phone: Eccles 3487-8-9 Grams: Beacon, Telex, Eccles

LONDON OFFICE: SELINAS LANE, DAGENHAM ESSEX. PHONE: DOMINION 2277/8/9
TGA TRI

Tick **No 132** on reply card for further details

A.I.D. A.R.B.

WHAT ARE YOU LOOKING FOR?

CONTROL VALVES!

GAS BOXES!

HYDRAULIC MECHANISMS!

We cover all fields from small CONTROL VALVES to COMPLEX FABRICATION for HIGH VACUUM WORK to intricate HYDRAULIC MECHANISMS with delicate instrument like sub-assemblies.

Facilities exist for: Ideally clean assembly to U.K.A.E.A. requirements—deep freeze testing to — 50°C also for design and development of equipment for your special needs.

SANDALL PRECISION CO. LTD.

WATLING STREET, BLETCHLEY, BUCKS

Tel: 3456-8 PBX *Grams: SANDALL BUCKS*

Tick **No 133** on reply card for further details

UKAEA
ENQUIRIES INVITED

S.M.P

PRECISION ENGINEERS

BRIEF PARTICULARS OF PLANT INSTALLED

LATHES: Capstan, Screw Cutting, Special Purpose.
MILLING MACHINES: Plain, Universal, Vertical, Special Purpose.
DRILLING MACHINES: Radial, Sensitive, Multi Spindle, Tapping.
GRINDING MACHINES: Plain, Universal, Surface, Internal.
BORING MACHINES: Single Spindle, Double Ended.
BROACHING MACHINES
AUTO SCREW MACHINES: Single Spindle up to 2¼" dia. Multi Spindle up to 2⅛" dia.
PRESSES: Up to 100 ton.

Stove Enamelling, Assembly, Lapping, Roto Finish, Plating, and Hardening Shops including H.F. Hardening

TOOLROOM, EXPERIMENTAL DEPARTMENT, AND OWN DESIGN AND DRAWING OFFICE.

★ Approved A.I.D., D.I.Arm., A.R.B. and also Approved tenderers to the U.K.A.E.A.

We are machining specialists in stainless and various high tensile steels.

SCREW MACHINE PRODUCTS LTD.
Wooburn Green, Nr. High Wycombe, Bucks.
Telephone: Bourne End 1444/8 (5 lines)

Tick **No 134** on reply card for further details

for CATHODIC PROTECTION

or WELDING INSPECTION

call in MAPEL

MAPEL

METAL & PIPELINE ENDURANCE LTD.,

Artillery Mansions, Victoria Street, London, S.W.1.
Tel: ABBey 6056 'Grams: Metaldure, Sowest, London

Divisional offices at Woolmer Green, Herts; also at Newcastle upon Tyne and Glasgow

AGENTS THROUGHOUT THE WORLD

Tick **No 135** on reply card for further details

Simple hydraulic bending

H.3 PR

Easy hand movement exerts controlled force of over 8 tons . . . ample for bending the thick-walled tubes increasingly used today. The double-acting hydraulic ram unit releases the bent tube from the former easily, without using wedges or hammer.

Write now for full details of the competitively priced TUBELA range of bending machines for hand, ratchet or hydraulic operation, including the 4-in. capacity Industrial Machines. One of them is bound to save you money!

Tubela

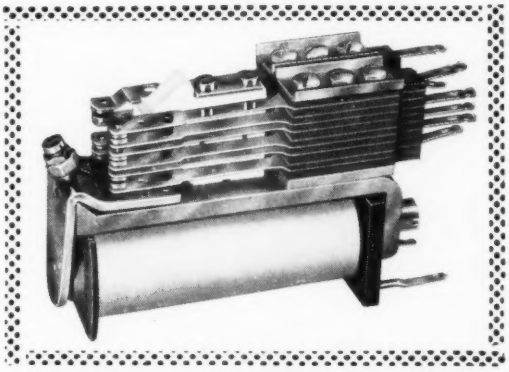
The Bending People

TUBELA ENGINEERING COMPANY LIMITED
North Eastern Office:
CUSTOMS HOUSE CHAMBERS
Quayside, Newcastle-on-Tyne
Telephone: 21180
Head Office:
FOWLER ROAD, HAINAULT
Essex. Tel. Hainault 4426-8

Tick **No 136** on reply card for further details

RELAYS

TO SPECIFICATION



POST OFFICE TYPE
3,000 and 600 RELAYS

Specialists in tropical and Services jungle finish.
Guaranteed to full A.I.D. and I.E.M.E. standards.
Prompt Deliveries Prototypes within 24 hours.

Post Office approved. All relays guaranteed made in our own works.

P.T.F.E. insulation now available.

SIMMONDS

Manufacturers to H.M. Government Departments and leading Contractors

L. E. SIMMONDS LIMITED, 5 BYRON ROAD, HARROW, MIDDX.
TELEPHONE: HARROW 7797/9 TELEGRAMS: SIMRELAY HARROW

Tick **No 137** on reply card for further details

ANCIENS ÉTABLISSEMENTS

AUBERT

ET

DUVAL

A. R. J. DUVAL, SUCCESSEURS

41, RUE DE VILLIERS - NEUILLY SUR SEINE

TÉLÉPHONE : MAILLOT 88-30 - R. C. SEINE 56 B 1399

ADR. TÉL. : FALATLAS-PARIS - TELEX 20.655

ACIÉRIE DES ANCIZES

(PUY-DE-DOME)

ACIERS ET ALLIAGES

RÉPONDANT AUX EXIGENCES DE

L'ÉNERGIE ATOMIQUE

Tick **No 138** on reply card for further details

TO INDICATE CONTROL OR RECORD

TEMPERATURE

For accuracy, ease of reading, robustness, economy and long, trouble free life install Rototherm Thermometers, Controllers and Recorders. Specialists in bi-metallic applications.

Write for details

Rototherm

BI-METAL · MERCURY-IN-STEEL · VAPOUR PRESSURE

THE BRITISH ROTOTHERM CO. LTD.

Morton Abbey, London, S.W.19 **LIberty 7661**

Midland Factory: Hollis St., New Basford **Nottingham 77847**

Tick **No 139** on reply card for further details

LEAD GLASS

for Protection from Radiation

Glass containing lead oxide for radiation shielding is available in three densities. These are 3.3; 4.3 and 6.1 gm/cc and their nominal lead oxide contents are 33%; 59% and 80%, respectively, which corresponds to metallic lead percentages of 30.6; 54.7 and 74.2. The lowest density glass is available in areas up to 4′ 6″ square and 10″ thickness. The 4.3 density, 4′ 6″ square and 8″ thickness. In both these cases, however, there is a maximum weight limitation of 2,000 lbs. The high density glass is available in volumes of up to 500 cu. ins.

The technical officers of the Association are always glad to give individual assistance.

LEAD DEVELOPMENT ASSOCIATION, 18 Adam Street, London, W.C.2
Telephone: WHitehall 4175. Telegrams: Leadevep, Rand, London

Tick No 140 on reply card for further details

SCINTILLATION SPECTROMETRY

Non-overloading Linear Pulse Amplifier NE 5202:

with 5 microsecond recovery for 100 times overload. Designed for scintillation spectrometry and pulse height analysis studies, this amplifier features high gain (50,000), high gain stability (better than 0.25% per week), good linearity, low noise (less than 40 microvolts at input), excellent overload characteristics, and operation at high duty cycles. Rise time 0.2 microseconds and integral linearity 0.15%. Preamplifier NE 5202A also available. Based on the double delay line differentiated Fairstein system, it consists of three high gain feedback groups and a White cathode follower output.

Resolving time 1.2 microsecs; 3-140 volts operating range with energy zero drift less than 0.05 volts per day; 0 to 10 volt gate width with less than 0.01 volts per day drift; maximum counting rate, 2×10^5 c.p.s.

Single Channel Pulse Height Selector NE 5102:

E.H.T. Supply Unit N.E. 5302:

with minimum of noise and ripple; output stability 0.01%; low noise and ripple—less than 1 mV RMS; output voltage continuously variable from 500-1800 V; output current 5mA.

E.H.T. Supply Unit N.E. 5303:

As NE 5302, but with output voltage range from 1000-5000 V.

containing White cathode follower preamplifiers with noise level of 25 microvolts; photomultipliers of 1" or 2" can be accommodated; for general use or for C14 and Tritium investigations with special rotary light locking device.

Shielded Scintillation Head Units NE 5501 and 5502:

Other Units Available:

Precision Ratemeter NE 5401 with eight ranges and six time constants.
Scanning scintillation spectrometer NE 8601.
Multi-channel scintillation spectrometer NE 8201 for industrial tracer investigations.

Scintillometers for geophysical exploration.
C^{14} and H^3 counting unit NE 8301.
Moisture and density gauge NE 8401.
Exclusive concessionaire for C.D.C./Bendix 100-channel Transistorised Kicksorter in Great Britain.
Sole agent for Harshaw Sodium Iodide Crystals in the United Kingdom.

For full details of the above and of our SCINTILLATION PHOSPHOR PRODUCTS (plastics, liquids, loaded liquids, crystals, gels, neutron detectors, and chemicals) write to

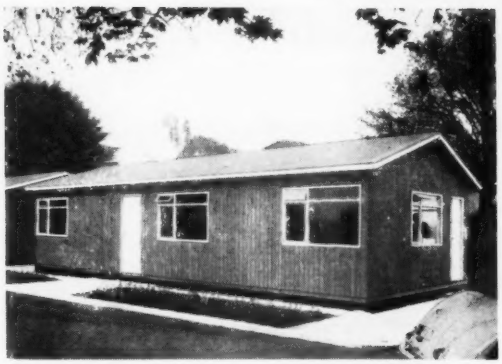
NUCLEAR ENTERPRISES (G.B.) LTD
SIGHTHILL, EDINBURGH, 11, SCOTLAND Tel: CRA 5262
Associate Company: Nuclear Enterprises Ltd., 1750 Pembina Highway, Winnipeg, Canada

(ndh) 708

Tick No 141 on reply card for further details

Low Cost Expansion

Office expansion is a continuing problem for both small and large industrial companies especially when capital costs and completion dates are of first importance.
The answer is **TYPE FOUR** the new range of low cost timber buildings which are immediately available and capable of fast erection.



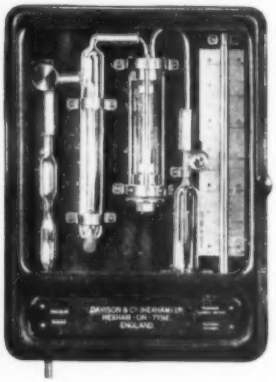
TYPE FOUR can be supplied completely transportable with 95% recoverability. Write for Illustrated Brochure, Design Sheet and Price List.

VIC HALLAM LTD
TIMBER BUILDINGS DIVISION
LANGLEY MILL · NOTTINGHAM
TELEPHONE: LANGLEY MILL 2301-7

Tick **No 142** on reply card for further details

THE "DAVISON" VACUMETER

A Mercury Column Vacuum Gauge for accurately registering the absolute pressure within a Steam Condenser

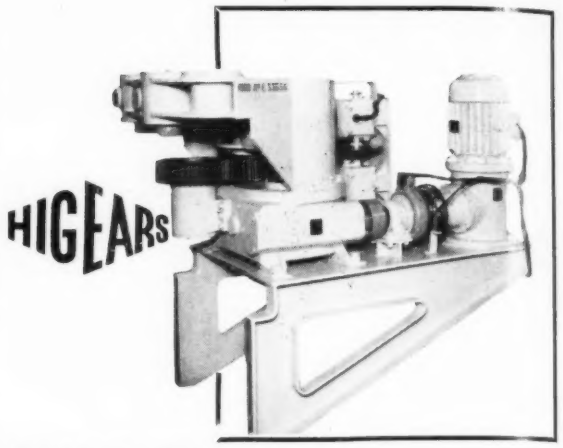


★ Standard Vacuum Gauges in Central Electricity Generating Board Power Stations.

★ Exported throughout the world and used on Turbine-driven Steamships.

DAVISON & CO. (HEXHAM) LTD.
(ENGINEERS)
HEXHAM-ON-TYNE **ENGLAND**
Telegrams: **" Davison, Hexham."** *Telephone:* **Hexham 7**

Tick **No 144** on reply card for further details



GEARED to your individual needs in special designs

HIGEARS . . . Gears and Gear Units of the highest quality . . . are available in a comprehensive standard range. Special HIGEAR Gear Units are also supplied, designed to meet individual needs. We are technically equipped to satisfy the most exacting requirements. One of our special designs produced for the Dounreay Fast Breeder Experimental Reactor is illustrated above.

HIGHFIELD **GEAR & ENGINEERING CO., LTD.**
NILE ST., HUDDERSFIELD.
Telephone: Huddersfield 4490 (3 lines)
Grams: Higears, Huddersfield.

Tick **No 143** on reply card for further details

TEST SIEVE SHAKER

for

accurate particle size analysis

Accurate and consistent results are the features required of a test sieve shaker for the sieve analysis of the particle size range of material. Simply vibrating or shaking test sieves by hand is not good enough for the standard of accuracy required these days. Vibration alone tends to aggregate rather than to segregate particles and shaking test sieves by hand is not only tedious but inevitably produces inaccurate results.

The **Inclyno Test Sieve Shaker** incorporates a double movement that jolts and spreads the test material ensuring perfect segregation of the various particle sizes and presenting the maximum number of apertures for undersize particles to fall through each sieve. Three models available for all sizes of standard test sieves and supplied complete with motor and inbuilt automatic time switch covering test periods up to 60 minutes.

INCLYNO

Write or telephone Crawley 25166 for List IN 3210

THE PASCALL ENGINEERING CO LTD
GATWICK ROAD · CRAWLEY · SUSSEX

Tick **No 145** on reply card for further details

Fabricated by

YARROW

. . . the bodies for 24 60" Tansphere Valves being supplied by Hopkinsons Ltd for Bradwell-on-Sea Nuclear Power Station

YARROW & CO. LTD
SCOTSTOUN, GLASGOW, W4
SCOTLAND

Tick **No 146** on reply card for further details

is this a record?

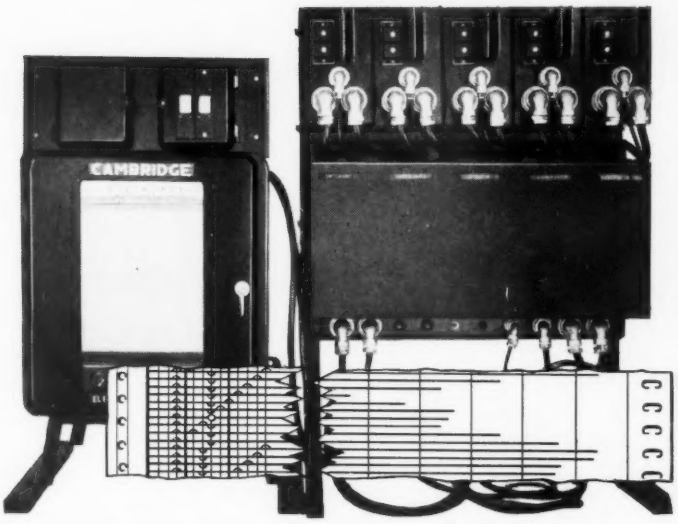
Yes, a record taken on the

Cambridge

IN-LINE SCANNING RECORDER

which provides

up to 400 records consecutively on one chart
All vital information on a single line
Positive and foolproof method of coding
Continuous print-out or Error print-out
and is suitable for thermocouples, resistance thermometers, strain gauges etc.



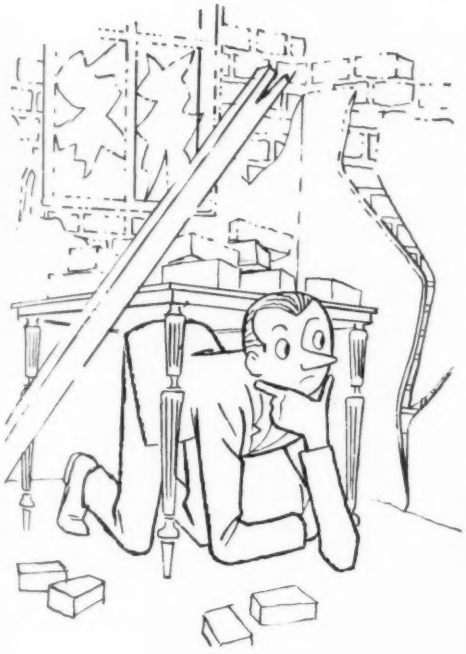
Conventional methods of identifying chart records are unsatisfactory if more than twelve points are recorded on one chart. The Cambridge In-Line Scanning Recorder overcomes these limitations by recording the desired information, i.e. measured value and identifying number, on a single horizontal line. It is designed to scan from 20 up to 400 points and, depending upon the requirement, will record each point sequentially, on demand or when the measured value is outside pre-set limits. It is based upon the single-point Model DE Electronic Recorder and can be made to revert to this function, drawing a continuous line on any selected point, by turning a switch.

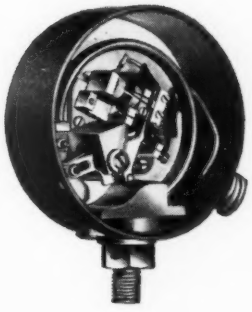
The recorder is supplied either as a self-balancing potentiometer, suitable for thermocouples, or as a self-balancing bridge, suitable for resistance thermometers, strain gauges, etc.

Send for List AP186 C. For future publications write for Mailing Form AP/6/59.

CAMBRIDGE INSTRUMENT CO. LIMITED 13 GROSVENOR PLACE, LONDON, S.W.1

How costly is your guesswork ?





Your margin of error is not likely to put you ' under the table ' in an explosive sense—but may we modestly affirm that the KDG range of Pressure Resistance Transducers *will* ensure constant and accurate measurement. Complete elimination of costly guesswork *is* possible with the close accuracy of the KDG Pressure Resistance Transducer.

There is a K.D.G. Instrument to meet your specific application

CRAWLEY KDG LONDON

K.D.G. INSTRUMENTS LTD.
In association with Stow & Partners Ltd.
MANOR ROYAL, CRAWLEY, SUSSEX
TELEPHONE CRAWLEY 25151

London Showrooms, Service & Sales: 100 Fleet Street, E.C.4. Tel. FLEet St. 5354/5

Tick **No 147** on reply card for further details

CLASSIFIED ADVERTISEMENTS

DISPLAY ANNOUNCEMENT RATES :— 1 insertion 40/- per single col. inch
6 insertions 38/- per single col. inch
12 insertions 36/- per single col. inch

LINEAGE ANNOUNCEMENT RATES :— 4/- per line. 5% discount 6 insertions, 10% discount 12 insertions

BOX Nos. :— 1/- extra will be charged

COPY DATE :— Advertisements for November issue to be received not later than 14th October

SITUATIONS VACANT

CONTROL ENGINEERS

A national control-engineering magazine wants a qualified and experienced man to act as a roving reporter.

He must be able to evaluate and report on control systems in a variety of industries. This is an excellent opportunity for a young engineer eager to take the broad view—he will get it in technical journalism.

He will also get a very good salary.

Details of age, qualifications, experience, ambitions, to Box No. NP 206.

COURSES

ROYAL TECHNICAL COLLEGE, SALFORD

An eight-weeks' course will be held at this College from Monday, 26th October to Friday, 18th December, 1959, inclusive on:

"The Science and Technology of Nuclear Power."

Full particulars and application forms can be obtained on application to:

W. G. Darvell, M.Sc., F.Inst.P., Head of Department of Pure and Applied Physics, Royal Technical College, Salford 5

R. RIBBLESDALE THORNTON, Clerk to the Governors.

SUPPLIES

THE RADIATION MONITORING SERVICE
provides a special Film and Holder for monitoring personnel working in the vicinity of X-rays or radio-active materials.
Details from:
41 LODGE ROAD, WEST CROYDON, SURREY
THO 8206

ORGANIC AND INORGANIC INDUSTRIAL CHEMICALS
•
CHEMITRADE LIMITED
17 Stratton Street, London, W.1
Telephone: GROsvenor 3422

Telephone your classified advertisement to **MUSEUM 8252**

AT YOUR SERVICE when you need an expert

ALUMINIUM DESIGN
and fabrication service available for all types welded and other light alloy structures and components
ALPHAMIN LTD.
4 Dunston Street, Kingsland Road, London, E.8. Tel.: CLIssold 4161

MANCUNA ENGINEERING LTD
DENTON, MANCHESTER
SPECIALISTS IN GAS CLEANING AND DUST TECHNOLOGY
District Office:
59 Victoria Road, Surbiton, Surrey
Tel: ELMbridge 9793

SHEET METAL WORK
All Materials · Skilled Work
MABBOTT & CO. LTD.
EST. 1901
SHEET METAL DIVISION
Phoenix Works, Poland Street, Manchester, 4. Collyhurst 1773

X-RADIOGRAPHY
of welds and castings offered up to 1½" thickness, also high vacuum test facilities.
IMMEDIATE SERVICE
THOS. RYDER & CO. MANCHESTER LTD.,
COMMERCIAL STREET WORKS, KNOTT MILL, MANCHESTER 15
Central 6753

Oblique Aerial Photographers for over 25 years
AERO PICTORIAL LTD.
REDHILL AERODROME, SURREY
Nutfield Ridge 3282
Contractors to C.E.G.B.

METAL SPINNING
Specialists in heavy-gauge hydraulic spinning in nimonic and stainless steel
●
Drakesons (General Metal Spinners) Ltd., 21 Parkhouse St., Camberwell, London, S.E.5
Telephone: RODney 5626 (3 lines)

PATTERN MAKERS
in wood and metal, also iron and non-ferrous castings
●
K. D. LEE
(Engineers' Pattern Makers) Ltd.
Roebuck Road, Chessington, Surrey
Tel: Lower Hook 1502

GAMMA RADIOGRAPHY OF PIPELINES
GAMMA AND X-RADIOGRAPHY OF TANKS AND PRESSURE VESSELS
Weld examination to Lloyds, etc. Quick, efficient services available for work on site now.
GAMMAX (LONDON) LTD.,
Cecil House, Wharfdale Road, London, N.1
Telephone: TERminus 0677 and 6925

Technical Translations
PERSONAL, PROMPT AND ACCURATE ATTENTION TO ALL YOUR REQUIREMENTS
THE WESTMINSTER TRANSLATION BUREAU
M. DANDO, M.A. D. S. TAVENER, F.I.L.
24 Wardour Street, London, W.1
TEL.: GERrard 4745

R. & J. PARK LTD
Dominion Works, Chiswick
England
●
Export packers, shippers and forwarding agents. Specialists in packing heavy machinery

C. W. GARRETT & SON
for
ALL DRAWING OFFICE SERVICES, PROCESSES, MATERIALS AND EQUIPMENT
●
WINDMILL ROAD, BRENTFORD
MIDDLESEX
Telephone : ISLeworth 4433 (4 lines)

SPECIALIST SUPPLIERS OF CUT-AWAY NUCLEAR MODELS INCLUDING FUEL ELEMENTS
●
MINIATURE ENGINEERING (LONDON) LTD.
Palace Chambers, Bridge St., London, S.W.1. TRAfalgar 5150

PROTECTION BY DAY AND WHILE YOU SLEEP
●
GERrard 4088
●
Security & Protection Services
3 Lower John Street, Golden Square, London, W.1

METRO ENGINEERING & PLATING WORKS LTD.
A.I.D. approved
Specialists in the Deposition of Metals
●
Parkfield Works, Long Lane, Hillingdon, Middlesex
Telephone: UXBRIDGE 4099

ALL LIGHTNING CONDUCTOR WORK CARRIED OUT
Steel Chimney Stacks Supplied and Erected
Guaranteed First Class Workmanship
●
J. CLOVER, Steeplejack
399 Chester Road, Sutton Coldfield, Warwickshire Tel: ERDington 1434

LABORATORY STAINLESS STEEL EQUIPMENT & PROTOTYPES
Manufactured to customers' own requirements
B O S S
Welding & Engineering Co. Ltd.
190 PENTONVILLE RD., LONDON, N.1
Telephone: Terminus 3598

ELECTRICAL CABLE FORMS
to customers' specification.
CHARLES BERNARD & CO. LTD.
721 North Circular Road, London, NW2
Telephone: GLAdstone 4019

HELICOPTER SERVICES Ltd.
OFFER THEIR AIRCRAFT FOR ALL CHARTER SERVICES
●
96 Piccadilly, London, W.1
Telephone: GROsvenor 5495-6
and **Luton Airport, Beds.**
Telephone: LUTON 4911

SPECIAL MACHINES AND APPARATUS DESIGNED, MADE AND INSTALLED TO ORDER
●
GEORGE WAILES & CO. LTD.
382/8 EUSTON ROAD, LONDON, N.W.1
Telephone: EUSton 3176

FIRE PROTECTION
Consult **EXTINGUERE Co. Ltd.,** suppliers of fire fighting equipment to Chapelcross and Hinkley Point.
●
88 Richmond Road, London, E.8
CLIssold 7550

TRANSFORMER MANUFACTURERS AND COIL WINDERS
●
Electric Windings (London) Ltd.
245 MILE END ROAD, LONDON, E.1
STEpney Green 5324

FOR ALL LONDON HOTEL ACCOMMODATION
Free Service · All Hotels · No Booking Fees
HOTEL BOOKINGS & INFORMATION LTD.
1/3 WEST STREET, LONDON, W.C.2
TEMple Bar 7158, 5045, 1161

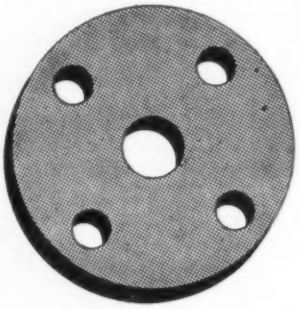
JAMES BRUTON & SONS Ltd
●
MANUFACTURERS OF VITREOUS ENAMELLED IRON SIGNS & PLATES
For all Purposes
87-89 Hedge Lane, PALmers Green
Palmers Green, London, N.13 6845 (2 lines)
Telegrams: " Enambrut, Norphone "

All Controlled Atmosphere
HEAT TREATMENTS
●
Heat Treatment and Brazing Co. Ltd.,
HERSHAM TRADING ESTATE, HERSHAM, SURREY
Telephone: Walton-on-Thames 20576

LYNTERDEX
LIMITED
THE INTERNATIONAL DISPLAY AND EXHIBITION SERVICE
SHEpherds Bush 3326
4 Shepherds Bush Road, London, W.6

ADVERTISERS IN THIS ISSUE

Advance Components Ltd.	56
Airmec Ltd.	20
Albright and Wilson (Mfg) Ltd.	47
Allen & Sons (Tipton) Ltd., W. G.	130
Armstrong Patents Co. Ltd.	52, 147
Associated Lead Manufacturers Ltd.	21
Atlas Steel Foundry & Eng. Co. Ltd., The	134
Aubert et Duval	154
Auto-Klean Strainers Ltd.	145
Autoset (Production) Ltd.	146
Avo Ltd.	38
Baker & Bessemer Ltd., John	132
Bailey & Co. Ltd., Sir W. H.	152
Birmetals Ltd.	78
Bitulac Ltd. (Paints Div)	134
Blackburn Electronics Ltd.	7
Bristol Siddeley Engines Ltd. (Beaver Ball)	42
British Acheson Electrodes Ltd.	53
British Ermeto Corp. Ltd.	63
British Industrial Eng. Co. Ltd.	4
British LaBour Pump Co. Ltd.	131
British Rototherm Co. Ltd.	154
Bronx Eng. Co. Ltd.	140
Burnett & Rolfe Ltd.	143
Burnley Aircraft Products Ltd.	8
Cambridge Instruments Ltd.	157
Cape Asbestos Co. Ltd.	16
Chance Pilkerton Ltd.	60
Chemical & Insulating Co. Ltd., The	121
Clay Cross (Iron Foundries) Ltd.	24
Consolidated Pneumatic Tool Co. Ltd.	27
Crosby Valve & Eng. Co. Ltd.	40
Darham Industries (London) Ltd.	141
Darlington Insulation Co. Ltd., The	74
Davison & Co. (Hexham) Ltd.	156
Distillers Co. Ltd., The	73
D. P. Battery Co. Ltd., The	18, 19
Edwards High Vacuum Ltd.	147
Electronic Assoc. Ltd.	135
Elliott Nucleonics Ltd.	66
E.M.B. & Co. Ltd.	58
Endicotts Filters Ltd.	152
Erhard, Johannes	32
Evers Ltd., H.	62
Evershed & Vignoles Ltd.	Cover 3
Evode, Ltd.	133
Fairey Aviation Ltd.	41
Fielden Electronics Ltd. (Pressure Div)	151
Fielden Electronics Ltd. (Temperature Div)	10
General Electric Co. Ltd., The	76
General Electric Co. Ltd. (Heavy Metals)	142
General Radiological Ltd.	144
Gordon Ltd., James	150
Grace & Co., W. R.	9
Graviner Mfg Co. Ltd.	26
Grazebrook Ltd., M. & W.	146
Hadfields Ltd.	13
Hallam, Ltd., Vic	155
Harland Eng. Co. Ltd. The	50
Harvey & Co. (London) Ltd., G. A.	22
High Voltage Corp. Inc.	117
Highfield Gear & Eng. Co. Ltd.	156
Hilger & Watts, Ltd.	130
Hoffman Mfg Co. Ltd., The	136
Imhof Ltd., Alfred	28
Imperial Chemical Industries Ltd.	80
Industries Atomique	138
K.D.G. Instruments Ltd.	157
Keith Blackman Ltd.	36
Kirk & Co. (Tubes) Ltd.	144
Kodak Ltd.	25
Lang Pneumatic Ltd.	39, 40
Lead Development Assoc.	154
Lewis & Co. Ltd., H. K.	126
Lincoln Electric Co. Ltd.	72
Lionweld Ltd.	11
Lockheed Precision Products Ltd.	67
Londex Ltd.	148
Lyons Ltd., Claude	132
Mallinson & Sons, Ltd., William	142
Mancuna Engineering Ltd.	14
Marston Excelsior Ltd.	45
Matterson Ltd.	54
M.B. Metals Ltd.	151
Metal & Pipeline Endurance Ltd.	153
Metalectric Furnaces Ltd.	145
Mirrlees, Bickerton & Day Ltd.	33
Morgan Refractories Ltd.	37
Mountford Ltd., Fdk.	136
Murex Ltd.	138
Murphy Radio Ltd.	149
New Metals & Chemicals Ltd.	79
Norwood Steel Equipment Ltd.	119
Nuclear Enterprises Ltd.	155
Nuclear Power Plant Co. Ltd., The	Cover 2
Nuclear Reactor Physics	128
Osborn & Co. Ltd., Samuel	35
Owen Organisation, The	15
Palatine Tool & Eng. Co. Ltd.	77
Pascall Eng. Co. Ltd., The	156
Paterson-Hughes Eng. Co. Ltd.	64
Phoenix-Rheinrohr AG	6
Plessey Nucleonics Ltd.	70
Powell Duffryn Carbon Products Ltd.	34
Power Auxiliaries Ltd.	65
Pyrene Co. Ltd., The	46
Pyrotenax Ltd.	48
Rawlplug Co. Ltd., The	17
Renold Chains Ltd.	55
Research & Control Instruments Ltd.	127
Roberts & Son Ltd., R. E.	43
Rocol Ltd.	44
Sandall Precision Co. Ltd.	152
Sangamo Weston Ltd.	75
Savage & Parsons Ltd.	5
Scientific Instrument Manufacturers Association of Great Britain, The	49
Screw Machine Products Ltd.	152
Serck Radiators Ltd.	12
Shell Chemical Co. Ltd.	68
Shell Mex & B.P. Ltd.	2, 3
Simmonds Ltd., L. E.	153
Simon Carves Ltd.	129
Simplifix Couplings Ltd.	57
Smith & Sons (Clerkenwell) Ltd., J.	128
Solatron Electronic Group Ltd., The	137
Spanner Boilers Ltd.	89
Stainless Steel Profile Cutters Ltd.	160
Stillite Products Ltd.	89
Streamline Filters Ltd. (	150
Super Oil Seals & Gaskets Ltd.	29
Superheater Co. Ltd., The	61
Taylor Stainless Metals Ltd.	141
Teddington Aircraft Controls Ltd.	51
Thermol Syndicate Ltd.	140
Thompson Water Tube Boilers Ltd., John	Cover 4
Tubela Eng. Co. Ltd.	153
Union Carbide Ltd.	149
Unistrut Ltd.	123
Vokes Ltd.	71
Vokes Genspring Ltd.	148
Wakefield Dick Industrial Oils	125
Wandleside Cable Works Ltd.	30
Ward Ltd., Thos.	139
West Instruments Ltd.	143
Western Detail Manufacturers Ltd.	31
Weston & Co. Ltd., Charles	23
Wiggin & Co. Ltd., Henry	82
Williams & James (Engineers) Ltd.	127
Yarrow & Co. Ltd.	156



STAINLESS TUBES & FLANGES

We offer in approved grades of Stainless Steel

★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES
★ SOLID DRAWN TUBES—FABRICATED PIPES
★ ROUND and HEXAGON BAR
★ PROFILES CUT TO ANY THICKNESS OR SIZE
★ CASTINGS TO CUSTOMERS SPECIFICATION

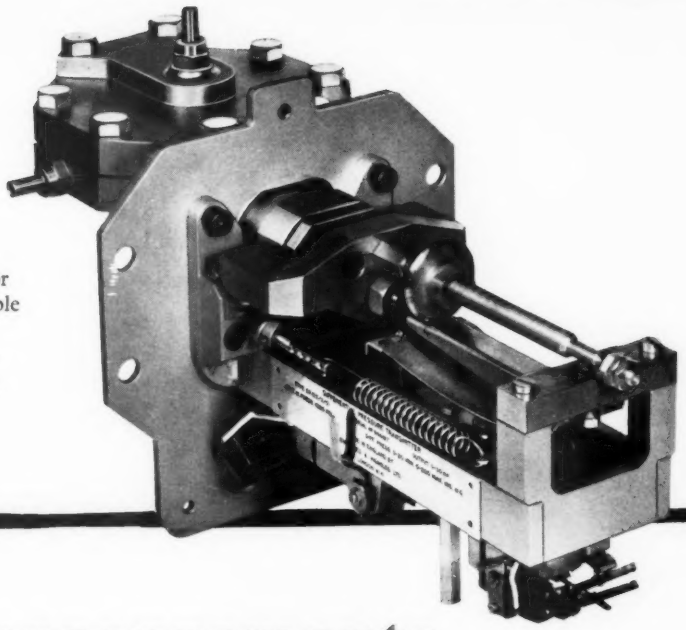
Keen Prices — Prompt Delivery

Send enquiries to Dept. N.P.

STAINLESS STEEL PROFILE CUTTERS LTD.

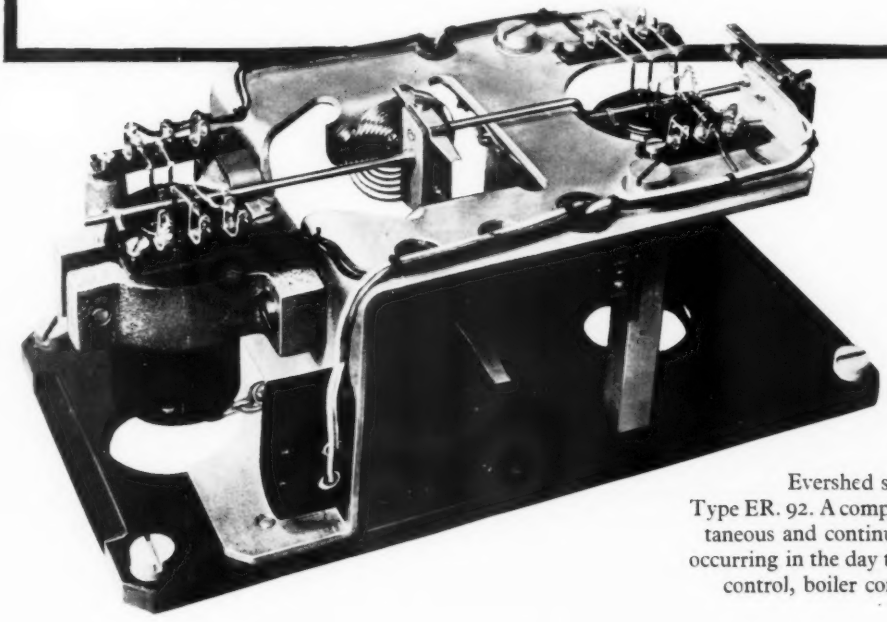
Farfac Works, Kings Grove, MAIDENHEAD. *'phone* 1522/23.

Tick **No 206** on reply card for further details



Evershed flow or differential pressure transmitter, Type ER.125, designed for accurate measurement and to give reliable service under the most exacting conditions. Suitable for oil, viscous or corrosive fluids, water, steam or gases.

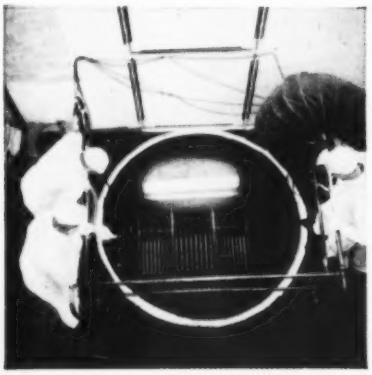
Where measurements matter most — You will find EVERSHED instruments



Evershed simple analogue computer, Type ER. 92. A computing device for the instantaneous and continuous solution of equations occurring in the day to day operation of process control, boiler control or the control of gas or fuel flow systems.

INSTRUMENTATION DIVISION EVERSHED & VIGNOLES LIMITED
ACTON LANE WORKS · LONDON W.4 Telephone: Chiswick 3670 Telegrams & Cables: Megger London Telex 22583
7/136

Tick **No 207** on reply card for further details



Clean conditions at Berkeley

Boilermaking is not usually associated with clinical cleanliness. But with nuclear power plant, conditions are different. In the heat-exchangers at Berkeley Nuclear Power Station, John Thompson's men are working in special clothing, with clean white gloves. They enter the vessels through sealed "penthouses" erected at the top of the heat-exchangers. The tube packs, which they fit into the vessels, arrive in sealed polythene wrappings. No incompatible materials are allowed to enter. The atmosphere is controlled — no corrosion must occur.

This is just another example of careful planning, work done to schedule, and an ability *to get on with the job no matter what the conditions.* It is typical of John Thompson.

JOHN THOMPSON WATER TUBE BOILERS LIMITED · JOHN THOMPSON GROUP

WOLVERHAMPTON